

**THE DEVELOPMENT OF A LOW-COST INTEGRATED MARINE  
NAVIGATION SYSTEM FOR LEISURE CRAFTS AND SMALL BOATS**

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**UNIVERSITI TEKNOLOGI MALAYSIA**

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Universiti Teknologi Malaysia**

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## ABSTRAK

Carta-carta nautika yang dihasilkan masa kini kebanyakannya khusus untuk kegunaan kapal-kapal besar yang mempunyai pelbagai peralatan dan kemudahan untuk mengendalikan carta-carta tersebut. Namun, bagi bot-bot kecil seperti bot nelayan dan perahu layar, kemudahan sebegini tidak ada bahkan masih menggunakan carta nautika konvensional yang ternyata kurang efektif kerana maklumatnya tidak kemas kini. Dalam era teknologi dan masyarakat bermaklumat masa kini, interaktif serta kemas kini seharusnya diberi tumpuan dalam penyediaan carta-carta nautika kontemporari. Sehubungan dengan ini, satu kajian ke arah pembangunan pangkalan data carta nautika digital telah dilaksanakan bagi penghasilan carta nautika digital bersifat vektor bagi kegunaan bot-bot kecil berkonsepkan *Geographic Information System* (GIS). Model konseptual bagi pembangunan pangkalan data carta nautika digital bagi kegunaan bot-bot kecil ini telah direalisasikan bersesuaian dengan persekitaran perisian CARIS GIS berasaskan carta hidrografi konvensional MAL 5622 bagi kawasan Pulau Langkawi. Hasil kajian dapat membantu pengguna membuat pelbagai pertanyaan (*query*) seperti untuk mencari laluan pelayaran terpendek, selamat, masa yang singkat serta menentukan halangan-halangan serta kawasan bahaya yang perlu dielakkan dan sebagainya. Tambahan pula, projek ini telah dibangunkan menjadi sistem *Web-based* dengan pembentukan *Nautical –WebGIS* untuk perkongsian maklumat carta-carta dalam Malaysia dengan adanya *Notice to Mariners* yang terbaru dari Tentera Laut Diraja Malaysia dan Jabatan Laut. Kawasan kajian juga telah diluaskan ke kedua-dua MAL 5 (Semenanjung Malaysia) dan MAL 6 (Sabah and Sarawak). *Nautical –WebGIS* akan mendorong pengguna menganalisis maklumat menerusi beberapa cara, seperti *drawing, zooming, searching and viewing reports*. Tambahan pula, *Nautical –WebGIS* telah diuji dan dikaji dari empat aspek, iaitu capaian *Web*, antaramuka laman *Web*, pemaparan peta dan fungsi *Web* laman *Web*.

## **ABSTRACT**

Nowadays, most nautical charts are specially produced for large vessels with various equipments and facilities for chart handling. However, such equipments are not available on small boats such as fisherman boats and yachts. In fact, these boats still used conventional nautical charts that are less effective because the data is not up to date. In this technological era with informative community, up to date, interactive information should be given attention in providing contemporary nautical charts. Therefore, a study towards the development of a digital nautical chart database has been carried out to produce vector digital nautical chart for small boat usage, with Geographic Information System (GIS) concept. The conceptual model for the development of digital nautical chart for small boat usage has been implemented that suits with CARIS GIS software environment based on conventional hydrographic chart, MAL 5622 for Langkawi Island. The result of this study can assists users to make many queries such as to find the safest and shortest navigational route with least time period, and identifying obstacles and hazardous areas that should be avoided. Furthermore, this project has developed Web-based GIS system to manage and visualize nautical charts online studies on the creation of Nautical –WebGIS for sharing the charts information throughout Malaysia with the latest Notice to Mariners from the Royal Malaysian Navy and Marine Departments. The area of this study covered both MAL 5 (Peninsular Malaysia) and MAL 6 (Sabah and Sarawak). The Nautical –WebGIS will enable users to analyses the information through several tools, such as drawing, zooming, searching and viewing reports. In addition, the Nautical –WebGIS is evaluated and tested from four aspects, which are Web accessible, Web interface, map display and Web function.

## **ACKNOWLEDGEMENT**

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In addition, special thanks to the CARIS Technical Support Consultants, Miss Elaine A. Doucette, Mr. France Castonguay and Mr. Jeff Sharpe for their contribution, especially in implementing the software CARIS. Thanks are also due to the software vendor of Autodesk MapGuide 6.3, Terradesic Sdn. Bhd. for providing a research license to pursue the research into a Web environment stage.

Last but not least, a special thanks to all research assistants and staffs at the Hydrographic Research and Training Office, Faculty of Geoinformation Science and Engineering, Universiti Teknologi Malaysia for their helps and sacrificed involving this project.

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background**

Aspect of surveying and charting in hydrography field are closely related in order to produce high quality data. In Peninsular Malaysia, navigational charts are published by the Royal Malaysian Navy (RMN), Ministry of Defence, Kuala Lumpur. They acted as a Hydrographic Office (HO) in the responsibility of producing Electronic Navigational Chart (ENC) with S-57 format according to the International Hydrographic Organisation (IHO).

With the improvement of Information Technology (IT), it has brought out the changes to vary organisations in Malaysia including hydrography. The most significant changes that can be seen are the technique of surveying. The instrumental of surveying is become more comprehensive to advance the quality of seabed surveying. Other than that, Global Positioning System (GPS) also implement in hydrography surveying to obtain an accurate and updated data. Thus, the nautical charts need to be managed in a systematic way so that it can be used as a reference for long term. Currently, the hydrographic data that presented in nautical charting are in the form of A0 size paper with different scales as shown in Table 1.1. The nautical chart is playing an important role for vessel navigation. It is because it contains the

navigation information such as buoy and beacon, radio, radar station, restricted area and shipping route. Data of depth also recorded in unit meter (m), fathoms or contours. Besides, it also included some physical features.

**Table 1.1:** Function of nautical chart

| <b>Type</b>  | <b>Scales</b>                   | <b>Function</b>   |
|--------------|---------------------------------|---|
| Small scale  | More or same with<br>1:500000   | For the planning of vessel navigation                           |
| Medium scale | Between 1:150000 to<br>1:500000 | For general uses  |
| Big scale    | Less or same with<br>1:150000   | To plan the route surrounding<br>coastlines when reaching port. |

(Source: RMN, 2003)

Form time to time, latest information regarding to the water area, such as damage of buoy or implementation of new port will be updated by the marine department and published to navigator through Notice to Mariners. The Notice can be checked directly by navigator through Web, which are <http://www.marine.gov.my> for Peninsular Malaysia, <http://www.jls.gov.my> for Sarawak and <http://www.marine.gov.my/sabah/sbh.html> for Sabah.

Nowadays, government of Malaysia hopes that Malaysia can be announced as a superior maritime country with high reputation within Asia water area. Therefore, the Malaysia Perspective Plan 2001 has invested RM1, 500 million for preparing a more completed and better infrastructures to compete with international vessels (Table 1.2).

The development of infrastructures are not only focus on main ports in Malaysia (e.g. Port Klang and Tanjung Pelepas) however it also pays attention to some small ports that has potential to be succeed as attraction of recreation.

**Table 1.2:** Planning of development for public infrastructures, 2001-2005 (RM millions)

| Section                      | RM Ke-7  |          | RM Ke-8   |
|------------------------------|----------|----------|-----------|
|                              | Planning | Spenses  | Plannning |
| <b>Transportation</b>        | 20 913.1 | 20 484.2 | 21 222.1  |
| Road                         | 12 429.9 | 12 269.5 | 14 002.6  |
| Town Transportation          | 404.2    | 404.0    | 705.6     |
| Rel                          | 5 450.3  | 5 450.3  | 4 081.0   |
| Port                         | 1 157.4  | 1 089.2  | 1 500.0   |
| Airport                      | 1 471.3  | 1 271.2  | 932.9     |
| <b>Public infrastructure</b> | 3 445.3  | 3 048.0  | 5 549.9   |
| Water Source                 | 2 776.8  | 2 382.7  | 3 966.3   |
| Others                       | 668.5    | 665.3    | 1 583.6   |
| <b>Communication</b>         | 51.0     | 39.6     | 228.0     |
| Communication and Pos        | 10.2     | 4.1      | 146.7     |
| Weather Services             | 40.8     | 35.5     | 81.3      |

(Source: Malaysia Perspective Plan 2001)

Currently, Malaysian who has own recreational boats is gradually increasing. For the future of Malaysia, some hydrographic applications in the development of nautical charting have to be implemented. Nautical chart needs to be digitalised. The concept of digitalised is to presenting the nautical charting in a vector or raster form. To advance the application, Geography Information Systems (GIS) should be integrated so that there will be a database to keep the information existing in nautical charting as a reference for users. Thus, a preparation of particular nautical charting for small boats and leisure crafts user should be implemented.

Moreover, with the improvement of electronic technology, it is now heading to Web-based GIS technology for efficiency data distribution as to secure the safety of vessel navigation. Web-based GIS is an application, which is distributed across a computer network to integrate, disseminate and visualize geographic information on the World Wide Web (WWW) (Gillavry, 2000). A Web-based user interface in the form of a map is providing an advanced view of the information. This also includes the capability to zoom in/out, turn on/off specific map features and to perform



queries based on measurement units or related geographic names. By using a compilation of Web technologies, such as JavaScript, XML and ASP, a customized interface has been created for many mapping website. All users, regardless of skill level, have the ability to retrieve and analyse a wide variety of information all through their Web browser. For that reason, Web-based GIS is a useful tool in presenting the nautical charts especially for data distribution.

## **1.2 Problem Statement**

Till now, Malaysia still not publishes particular nautical charting for recreation of coast area and also other users, navigator that using small boats and leisure boats needs to refer the paper nautical charting that existed to obtain the latest information. However, the information that obtained from paper nautical charting is in static form. It made the manually chart work became sophisticated. Therefore, initiative to the development of low-cost digital nautical charting application is the main purpose in this research for the small boats and leisure crafts in Malaysia.

Producing of Electronic Navigational Chart (ENC) in Malaysia started by Lim Joon Chai (2000). It was made to prepare a data set ENC S-57 in Malaysia water area for Electronic Chart Display and Information System (ECDIS) on board. According to the rules that fixed by International Convention for the Safety of Life at Sea, 1974 (SOLAS), only vessels SOLAS that navigate across ocean must use a completed ECDIS with the data source from ENC S-57. Thus, other transportation of water that not related with SOLAS is excluded.

Therefore, small boats and leisure crafts are free to use any other systems that are suitable for them with different size and cost. But, Electronic Chart System (ECS) are different with ECDIS as mostly ECS could not help much in vessel navigation to secure the safety of vessel. It makes the navigator has to be sensitive and always update the chart information for their own ECS from time to time.

Furthermore, since the nautical charts are widely used, navigators will definitely seek for the latest information about nautical chart and Notice to mariners in order to success their works. The insufficiency way of distributing the updated information from different departments in different method will take too long to reach the end user and it would confuse the users as well. Thus, this would surely affect their working progress.

To solve the first problem, it is needed to develop a low cost nautical charting for small boats and leisure crafts in the form of vector based. The chart that going to be developed are suitable to be used for planning application of small boats navigation because it able to provide the accurate and useful information for navigators.

For the second problem, these nautical charts and Notice to mariners should be integrated for the needs of safety information. To overcome these problems, it is important to propose Web-based GIS system to manage and visualize nautical charts online.

### **1.3 Research Objective**

There are some objectives have defined to success the two phases of research. For the first phase (produce a low cost digital nautical charting in vector form for small boats and leisure crafts in Malaysia), there are:

- (i) Literature on the needed of hydrographic and topographic data that will be included in presenting the digital nautical charting in vector based particularly related with specification data S-57.

- (ii) Develop a nautical charting with database of hydrographic information for the needed of small boats and leisure boats navigation using CARIS GIS 4.4a.
- (iii) Implement some accurate analyses of spatial and attribute on the data that has produced in the need of user.

For the second phase (produce a online system for displaying and analysing nautical charts for Malaysia or), there are:

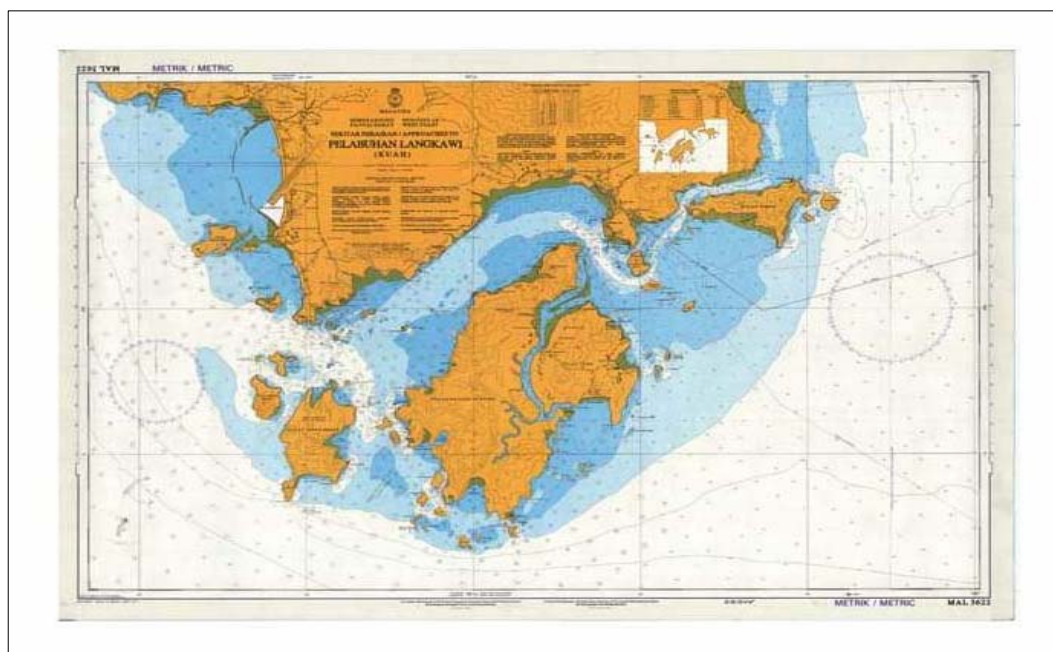
- (i) To design and develop a Marine Information System that can integrate updated nautical charts and the Notice to Mariners for publishing in a Web platform.
- (ii) Test and evaluate the result of application based on its performance.
- (iii) To analyses the information of charts on various purpose such as safety navigation, traffic control and obstructions.

#### 1.4 Research Scope

In the first phase of this research, the study area is water area surrounding Port Langkawi. Port Langkawi is chosen because it is one of the popular destinations for small boats in Peninsular Malaysia. The source of data is the paper nautical chart MAL 5622, which published by hydrographic department, TLDM. The information of the study area is shown in Table1.3 and Figure 1.1.

**Table 1.3:** Geography reference for MAL 5622

|                         | <b>Minimum</b>    | <b>Maximum</b>     |
|-------------------------|-------------------|--------------------|
| Latitude ( $\phi$ )     | 6° 08' 19.084" N  | 6° 22' 00.480" N   |
| Longitude ( $\lambda$ ) | 99° 38' 45.250" E | 100° 00' 22.676" E |



**Figure 1.1:** Study Area of Phase 1 - MAL 5622

To implement this research, there are some software are needed:

- (a) CARIS GIS 4.4a (including CARIS Setup, CARIS Tools, CARIS SAMI, CARIS Editor, CARIS Information Manager, CARIS Database Manager), by Universal System Limited, Canada.
- (b) Microsoft Excel 2000, by Microsoft.
- (c) Wide Image (for scanning uses).
- (d) ScanPlus III 810c (Colour) Calcomp.
- (e) Computer with the specification that can cope with CARIS GIS 4.4a:
  - (i) Using the Windows 2000.
  - (ii) Pentium II processor.
  - (iii) Random Access Memory with at least 64 RAM.
  - (iv) Three button mouse.
  - (v) Parallel port.
  - (vi) Monitor with 17" in size.
  - (vii) Video card of 8 MB.
  - (viii) CD-ROM drive.

CARIS GIS 4.4a was chosen to implement this research because it is software that used to produce ENC S-57 by IHO. Other than that, it also prepares

some object codes, symbols that cope with S-57 specification and international symbols for International Nautical Chart (INT1).

In the second phase of this research, the study area has expanded to a whole Malaysia and in the form of nautical chart in paper format. Researcher will digitise the latest edition of MAL 5 Peninsular Malaysia – 1: 1 250 000 (Figure 1.2) and MAL 6 Sabah and Sarawak – 1: 1 250 000 (Figure 1.3) into digital format whereas others nautical charts which contain small areas in Malaysia will be used in raster image for developing the application.



**Figure 1.2:** Study Area of phase 2 – Peninsular Malaysia (MAL5)



**Figure 1.3:** Study Area – East Malaysia (MAL6)

The GIS software that will be used for developing a Web-based GIS in presenting the nautical charts is Autodesk MapGuide 6.3. Autodesk MapGuide 6.3 enables non-technical end-user to access and interact with intelligent maps through their web browsers easily. It is fast and easy to set map display properties, the level of interaction within a map and links to external data sources.

## 1.5 Importance of This Research

The first phase of this research is a pilot project to develop digital nautical charting in vector form using CARIS GIS 4.4a whereby the details of procedure will be shown in this reports. Other than that, the result of the first phase can reduce the burden of navigators in providing a efficient and low cost digital nautical charting for them as a reference for navigation.

The second phase of this research is to provide an efficient way of data distribution by enhancing the data management. With a better data sharing system, it

gives an opportunity for a better working environment, particularly to navigator. Indirectly, it minimizes the cost of a project due to the proper data sharing system that implemented.

## **CHAPTER 2**

### **DEVELOPMENT OF NAUTICAL CHARTING**

#### **2.1 Background**

As we know that, a paper chart or a nautical chart and the notices to mariners are both necessary tools for vessel navigation. In this modern society, the development of the technology has result in the rapid changes of the presentation for nautical chart but the notices to mariners are still presented in hardcopy. Paper chart has now become the electronic chart whereby it can be presented in a computer instead of a paper. It can be used for developing Electronic Chart Display and Information System (ECDIS), Electronic Chart System (ECS) and Raster Chart Display System (RCD).

Those examples of systems that use electronic chart have introduced a new level of performance into vessel navigation and it is now leading to major changes in maritime navigation. It has the potential to present all necessary chart and navigational-related information required for the safe operation of a vessel. With the help of GIS, some of the functionalilities can be enhance particularly data management.



## 2.2 Earliest Charts

The earliest chart that used for navigation was known as pertolan chart created by Juan de la Cosa in 1500 (Figure 2.1). It was a miraculous product of the late Middle Ages. When the use of compass has become universal, hundreds of copies was produced because it was used with slight improvements for actual vessel navigation for over three centuries. Most charts have 16 or 32 compass roses with radiating rhumb lines (lines showing compass direction), a motif often inserted on modern maps as decoration.



**Figure 2.1:** Portolan chart were the result of compass survey

In 1700, the charts were produced with more detail information and accurate whereas they are far less decorative. When it turns to nineteenth century, the charts has become diversify regarding to the certain needs and uses. Those charts were nautical charts, submarine, thematic, magnetic, oceanography and others.

## 2.3 Nautical Charts

A nautical chart is actually more than a bathymetric chart or a land map. It shall contains all data required for both position fixing and route finding, as well as for the avoidance of dangers and the safety of navigation in general. For bathymetric charts in hydrographic fair sheet or the data plot cannot be considered the end product as it is not yet in the form most suitable to the use of navigator or the oceanographer is expected to make of it. Nautical charts must be easily discernible also during bad weather and minimal lighting on the bridge of a vessel. (Langeraar, 1984)

The totality of information on a nautical chart can roughly be divided into three main components, namely:

- (i) Under water topographic features, natural as well as man-made ones.
- (ii) Topography of the land as far as of interest to the navigator.
- (iii) All further information related to the problems of positioning.

For all three components the main question will always be how to ascertain the reliability of the basic information on which these three components have to be found. With regard to component one, under water topography, the main source of information will be either hydrographic survey results of the own service for sea areas under national jurisdiction, or nautical charts prepared by foreign hydrographic offices for other sea areas. Component two, land topography, comprises all information of importance to the orientation or positioning of the navigator, including coast lines, position of ports and harbours, contour lines and others. The component three will consist information related to position fixing as far as not covered under component two. It comprises the chart's graticule of meridians and parallels, possibly a metric grid and others.

### **2.3.1 Notice to Mariners**

Due to the high cost and time consuming for the production of a nautical charting, therefore Notice to Mariners was published as the correction for the current nautical charting. In Malaysia, Marine Department of Malaysia publishes Notice to Mariners; in contrast Royal Malaysian Navy publishes nautical charts.

Basically, some of the information that wrote in the Notices to Mariners are new light beacons established, light beacon collapsed, relocation of buoys position, installation works of pipeline or platform and others. The Notice to Mariners are in the form of paper sheet and it will shows the position, chart affected, date, time and also danger height related with the happening.

## **2.5 Electronic Chart**

Electronic chart able to present a number of advantages compare to traditional paper chart includes information from other sources (e.g. List of Lights and sailing directions), vector structure of information allows maximum possible automation of navigation safety control and combined with modern navigation devices.

The term ‘electronic chart’ is a collective name that covers many types of systems displaying chart information on a computer screen. There are two types of electronic charts that are raster charts and vector charts.

### **2.5.1 Raster Charts**

Graphic display of the data on a raster chart basically corresponds to that contained on a paper chart. During the scanning process, a faithful reproduction is obtained of all the information present on the paper chart. This primarily applies to the graphic elements of the chart including symbols, lines, wording and the chart borders. The colours of the displayed raster chart can be modified and need not to be identical to those of the paper chart. (Hecht et. al., 2002)

Since the colour of the raster data can be changed, it is possible to produce colour sets to suit various light conditions on the symbol. However, this is best to be accomplished when the chart original has been used for scanning.

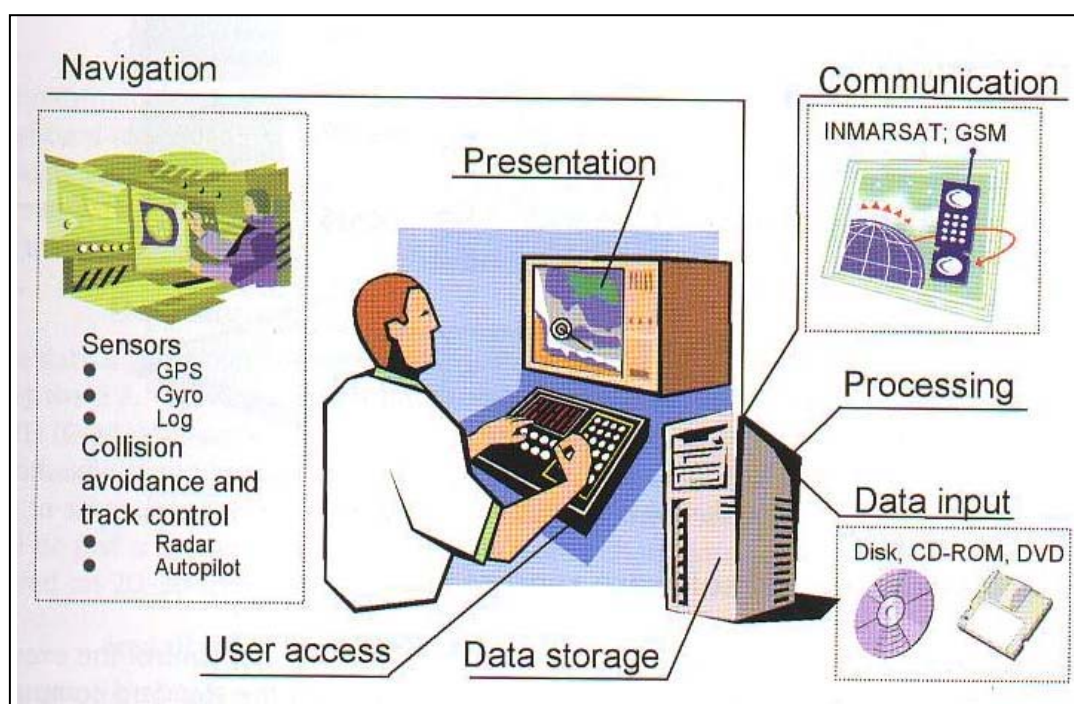
### **2.5.2 Vector Charts**

The process of graphic visualization for vector chart data is more complicated but also more flexible than that for the raster charts. While, it is possible for raster charts to change the colours of the pixels from the original, the text and symbols remain the same of the paper chart. This is not so with vector charts. In this case, the allocation of the graphic symbols is affected by the reading and interpretation of the data by computer software. (Hecht et. al., 2002)

Vector chart is independent of the original paper chart. In this process, the chart graphics of vector data are produced separate from the chart presentation and are not dependent on the print or scan quality. Although one would not to do so for acceptance reasons, it is even possible to produce graphic symbology completely different from that of the traditional paper chart symbols.

## 2.5 Electronic Chart Systems

In many respects, electronic chart systems are the first shipboard navigational devices using the basic components of computer technology. The basic hardware components and interfaces common to all electronic chart systems include Central Processing Unit (CPU), colour monitor as a display device, keyboard and track ball for human interface, data storage, communication interfaces and also interfaces to other navigational devices. (Figure 2.2)

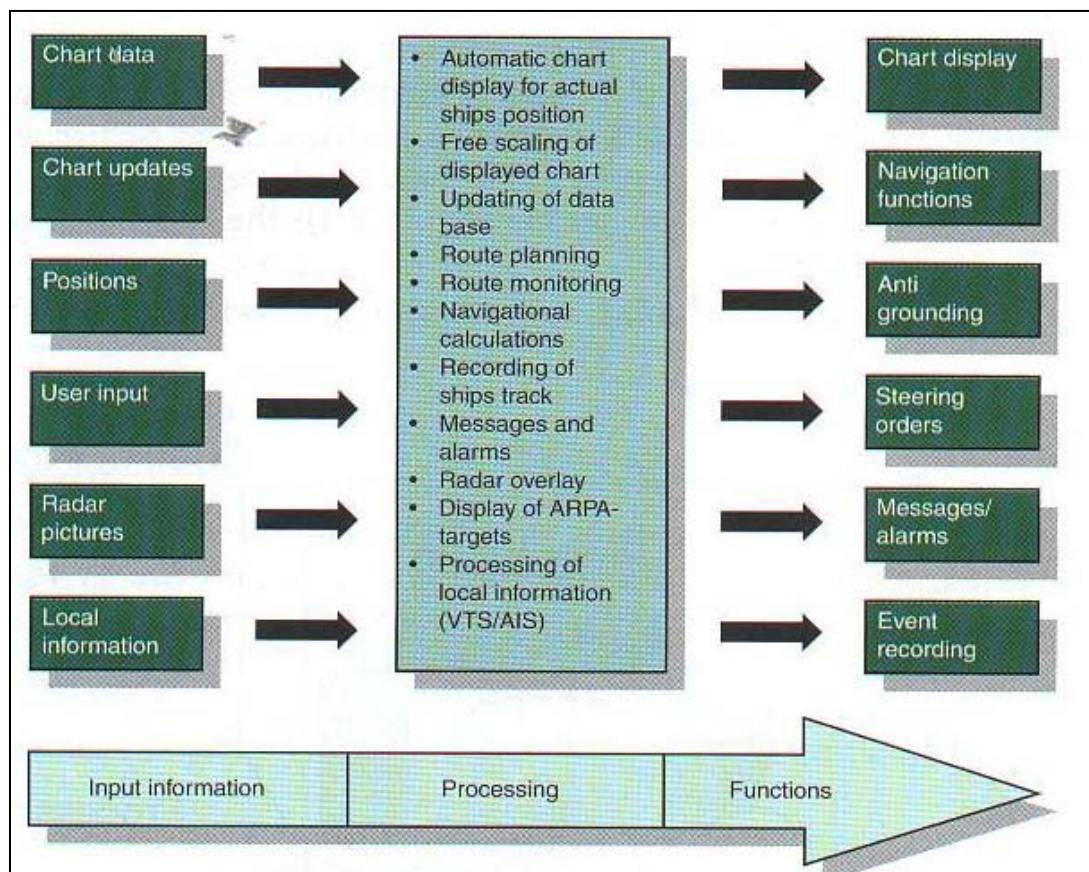


**Figure 2.2:** Basic components of an electronic chart display system and the interfaced navigational devices

(Source : Document *The Electronic Chart* by Hecht et, al., 2002)

Special software programs control the operation of these components. Their fundamental elements include Graphical User Interface (GUI) and also Kernel software, which control data management and presentation of chart information.

The chart information is stored in the form of a database containing all the geographic hydrographic administrative and geophysical information for the area that is traditionally provided by paper charts. Furthermore, all other information and events of navigational importance are stored and made available for display under operational conditions (e.g. waypoints, routes, position fixes and the past track of a vessel). The general information flow of electronic chart system is shown in Figure 2.3.



**Figure 2.3:** Information flow within an electronic chart system

(Source : Document *The Electronic Chart* by Hecht et, al., 2002)

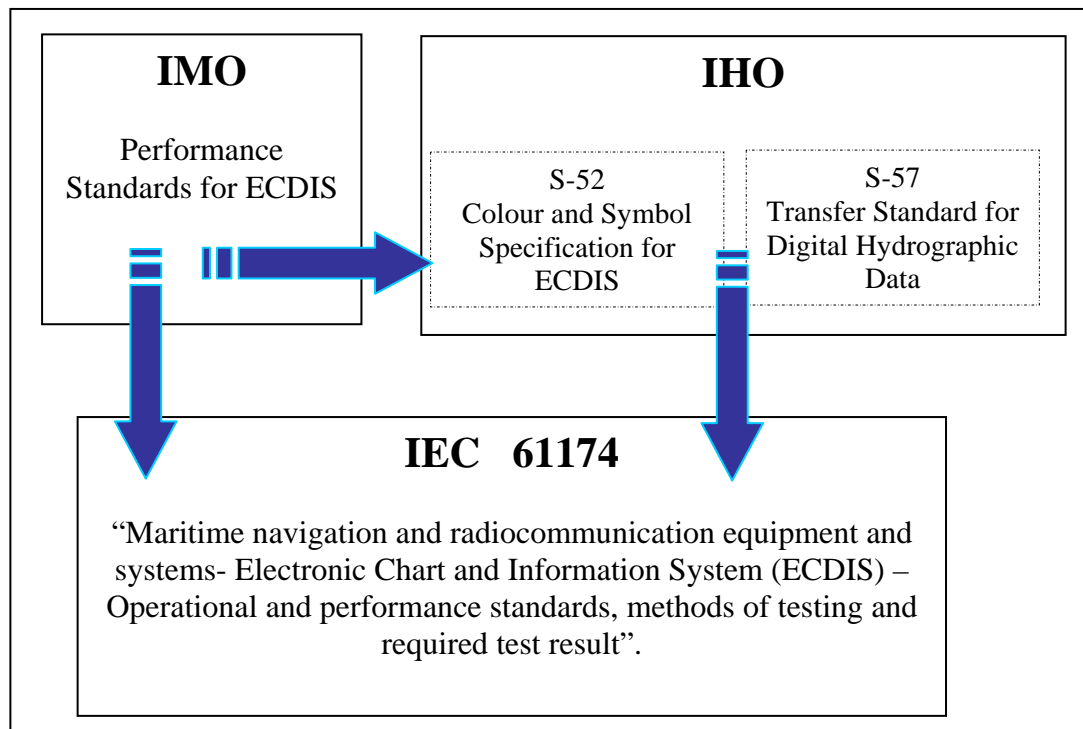
Well, there are several types of electronic chart systems and not all have the same capabilities or function in the same way. The mainly differences of between

various types of system are format and contents of the chart data, chart display and availability of navigational functions. Based on the above criteria, there are three basic types of systems that are Electronic Chart Display and Information System (ECDIS), Electronic Chart System (ECS) and Raster Chart Display System (RCDS),

### **2.5.1 Electronic Chart and Display Information System (ECDIS)**

Electronic Chart and Display Information System (ECDIS) is a system that consists of the official chart. To be considered as official chart data must meet two requirements. One that is authorized by a national government agency, normally the national hydrographic office and two that it meets the specifications of the International Hydrographic Organization (IHO). In a simple way, ECDIS uses Electronic Navigational Chart (ENC) as its data and not electronic chart. It is in vector format. The IHO has defined a uniform data exchange format – ‘Transfer Standard for Hydrographic Data’ [IHO S-57, 1996] for ENC and presenting the ENC on the screen is specified in another IHO standard, the ‘Colours and Symbols Specifications for ECDIS’ [IHO S-52, 1996].

In order to be called as ECDIS, the equipment that is to be installed on board must do much more than just properly display the stored chart data and it must support the whole range of navigational functions that make use of the characteristics of the chart data and their specific presentation. For this reason, the International Maritime Organisation (IMO) has developed a standard describing the minimum of functional requirement of an ECDIS – the ‘Performance Standards for ECDIS’ [IMO ECDIS, 1995]. In addition, it must pass type approval and test procedures developed by the International Electrotechnical Commission (IEC) and based on the IMO and IHO requirements. The Figure 2.4 shows an overview of co-operation of the three above-mentioned organizations and the description of the standards developed by them.



**Figure 2.4:** International Standards for ECDIS and the participating organisations.

ECDIS acts as information system and offer additional information about the characteristics of the displayed features besides the graphic presentation of the chart. Within the ECDIS, the ENC database stores the chart information as lines, areas or geographic objects. Appropriate mechanisms are built into the system to query the data and then to use the obtained information to perform certain navigationanl functions.

### 2.5.2 Electronic Chart System (ECS)

Generally, all of the systems that are not capable of meeting the ECDIS performance standards can be generically defined as Electronic Chart System (ECS). This can be happended because they do no use the official ENC data that has been



issued by a hydrographic office or they have limited functional capability that does not match the requirements specified by IMO.

ECS is using privately sourced data offer a good range of functionalities, several also display the official vector data and raster data. However, the private sources can only guarantee to a limited degree the completeness and correctness. They are not capable of being considered equivalent to nautical paper charts. But, this has not prevented ECS from getting widespread acceptance and considerable success. Nowadays, number of ECS equipped SOLAS vessel is much higher compared to the number vessel carrying and operating an IMO compliant ECDIS. ECSs have firmly established the idea and the use of electronics charts display systems onboard. Truly, for legal reasons the paper chart remains the official base for navigation onboard and cannot be left home in case the vessel operates with ECS.

### **2.5.3 Raster Chart Display System (RCDS)**

The data for the Raster Chart Display System (RCDS) is raster charts. Raster charts can be obtained through a scanning process (e.g. an optical, electronic line-by line capturing process of information contained on paper charts). When properly displayed, raster data can be a faithful reproduction of the information contained in a paper nautical chart.

However, the raster data allow only the screen display of the pictures of the paper charts whereby the vector data contain the objects' characteristics and open a completely new dimension in chart display and navigational functions. Thus, an electronic chart system in RCDS mode does not provide the full functionality of ECDIS.

There are a lot of weaknesses for RCDS when it compares with the ECDIS. It is because it does not provide the different scale charts, the look-ahead capability

may be somewhat limited and this may lead to some inconvenience when determining range and bearing or the identity of distance objects. The orientation of RCDS display will be affected the readability of chart text and symbols (e.g. course-up, route-up) due to the excessive zooming in or zooming out. It is because the raster charts are made up of cells or pixel. Therefore, it may not be possible to interrogate Raster Navigational Charts (RNC) features to gain additional information about charted objects.

## **2.6 Electronic Navigation Chart (ENC S-57)**

ENC S-57 is a set of standard specification that developed to enable HO and other private companies to produce ENC S-57 with a consistent format. Thus, the ECDIS can be implemented in an efficient way with a completed set of ENC S-57 data that cope with IMO Performance Standard for ECDIS.

### **2.6.1 Data Model of S-57**

Data model for ENC S-57 has been classed to four types of feature objects, which are geo, metadata, collective and cartography as below:

(i) Geo Object

Including all the descriptive features that related with real world entities.

(ii) Metadata

Including the background information for some objects or data (e.g., scale compilation, datum, publication date and others).

(iii) Collective

Information inter-related with other objects.

(iv) Cartography Object

Including the cartography information for the real world entities.

## **2.7 Process of Producing ENC S-57**

Basically, the process of producing ENC S-57 involves three main components; there are data source, data and product. The data source is referring to the methods to obtain data such as hydrography surveying, paper charts or other maps that related. Data means database of electronic navigational chart that based in vector format and it is formed by varies set of data files. However, product means the end product that will be received at the end of the process.

ENC S-57 also a kind of data for digital nautical chart in the form of vector format. Vector data file able to keep the image on screen as a discriptive object. Normally, it represents the information as below:

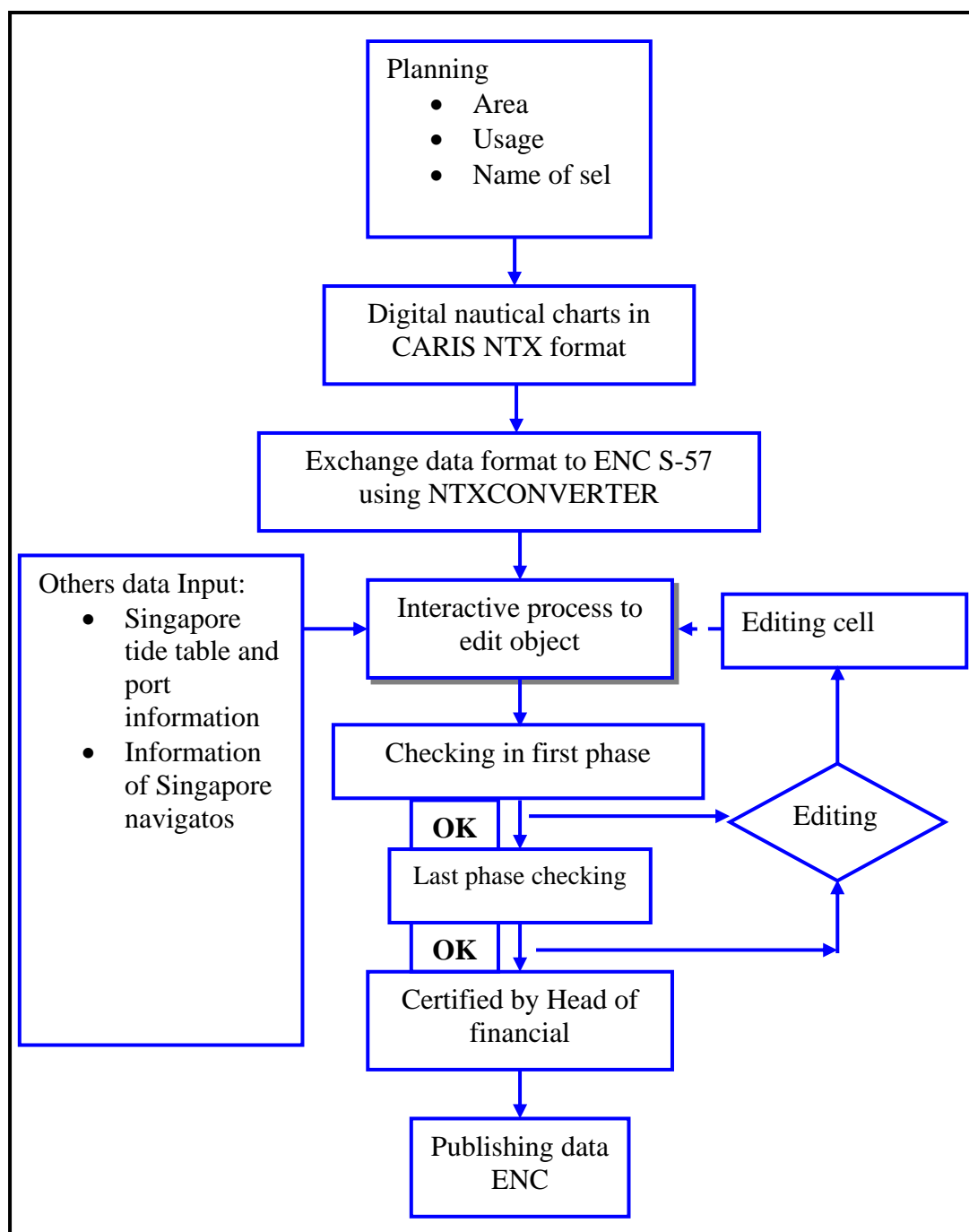
- (i) A series of points (latitude/longitude) in explaining connected nodes for different polyline segment surrounding coast area.
- (ii) A point (latitude/longitude), which can provide the position of depth.
- (iii) A point (latitude/longitude), which can provide the position of navigational symbols.

- (iv) Text (e.g., name of places) and its positions.

One of the method in implementing the development of database for this digital nautical chart data is through the on-screen digitization using CARIS GIS. Different key or ID represents each object or feature but it could be in same or different layers. The key or ID can act as primary key, which build the relationship between data spatial and data attribute in database.

Source data that normally used to produce ENC S-57 must be paper nautical charts and information from the latest surveying that published by HO.

In order to implement the development of ENC S-57, information that keep in the nautical charts need to be arranged according to certain thematic layers, such as depth information, topography, magnetic, tide, metadata, port utilities, obstructions or dangerous objects and others. The purpose of arranging is to smooth the query towards data attribute in database as well as the data spatial that will be developed. Figure 2.5 shows the example of implementation of ENC S-57 that practised by Singapore Hydrographic Department.



**Figure 2.5:** Flow chart of process in producing ENC S-57 (Edition 3 and 3.1) by Singapore Hydrographic Department (Source: Wilson, 2002).

## 2.8 Problems in Producing Data ENC S-57

Producing data ENC S-57 is not a simple work. One of the problem that always occurred and related with producing data ENC S-57 is involve the standard specification of S-57 itself. For earlier group that involved in producing ENC S-57, they forced to go through three times of reproducing data ENC S-57 due to the updating or correction towards the data structure in standard specification of ENC S-57 that published in different edition. However, the final standard specification had published and compiled in standard specification of ENC S-57 Edition 3.0 whereby it has explained in detail regarding the need of ENC as below:

- (i) Product Specification for ENC
- (ii) Updating Profile for ENC

There are some obvious problems that facing by all of the HO or private publishers:

- (i) The use of suitable tools to execute Quality Assessment (QA) and Quality Control (QC).
- (ii) The need of training for staff so that they can cope with the procedure of producing ENC in short period.
- (iii) Existing of different interpretation towards ENC contents.
- (iv) Problems related with the need of data hydrography surveying for critical areas such as port authorities to produce navigational chart in super scale.

## 2.9 Status of Producing for ENC S-57

In the VI meeting of IHO WEND in Norfolk, Virginia within 18 to 19 May 2001, it was known that some of the produced ENC S-57 did not fulfil the requestment of user completely and it led to the failed of functional ECDIS. In details, attention paid more to existing ENC S-57 for commercial uses till the day before that meeting began. Therefore, that meeting decided WEND to launch a study on certain ENC S-57 in the whole world. The study included some aspect as below:

- (i) Future planning for improving the publication of ENC S-57.
- (ii) Inter-connected within the existing ENC S-57 with the main vessel path.
- (iii) The need of aid and training to solve the above problems.

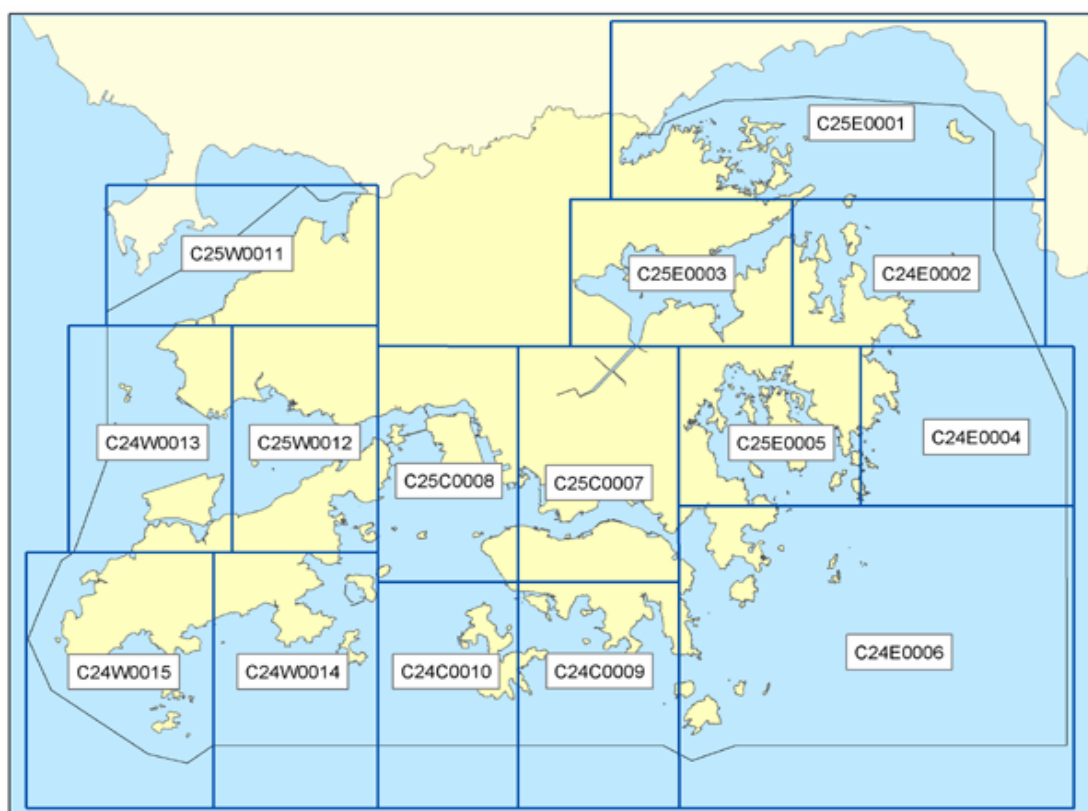
The International Hydrographic Bureau (IHB) has requested the collection of ENC for the countries that relevant with the problem. The result of that study (**Appendix A**) shows the collection of ENC S-57 that has implemented and it could be classed to three groups as below:

- (i) ENC S-57 that still in process of planning or producing are shown in red border.
- (ii) ENC S-57 that has done, but not yet published in commercial way are shown in blue border.
- (iii) ENC S-57 that has been published for commercial used are shown in black border.

However, the information of study is not enough to give a clear look, whereby there will be some mistakes in grouping the classes cause some of the sel that has classed is not accurate. In addition, the limitation of cell for ENC S-57 that presented in **Appendix A** might not able to provide the real area of data ENC due to lack of some area and chart (refer to Website [http:// www.iho.shom.fr /ECDIS/ WebCatalogue/ ENC\\_Coverage.htm](http://www.iho.shom.fr/ECDIS/WebCatalogue/ENC_Coverage.htm) ). The coming sub topic will give an example of ENC S-57 that has done in the planning for water area in some countries.

### 2.9.1 Example of ENC S-57 for Hong Kong Area

ENC S-57 for Hong Kong could be divided to 15-geography locations included the whole water area of Hong Kong. Each geography location formed a cell and each cell given a purpose of nautical usage. Figure 2.6 shows the cells that within Hong Kong water area whereby Table 2.1 shows the publication of cell that has been finalised in 12 March 2004.



**Figure 2.6** Cell of ENC S-57 for Hong Kong area

(Source: <http://www.hydro.gov.hk/enc/images/encindex.png>)



**Table 2.1** List of ENC S-57 for Hong Kong area(Source: <http://www.hydro.gov.hk/enc/coverage.php>)

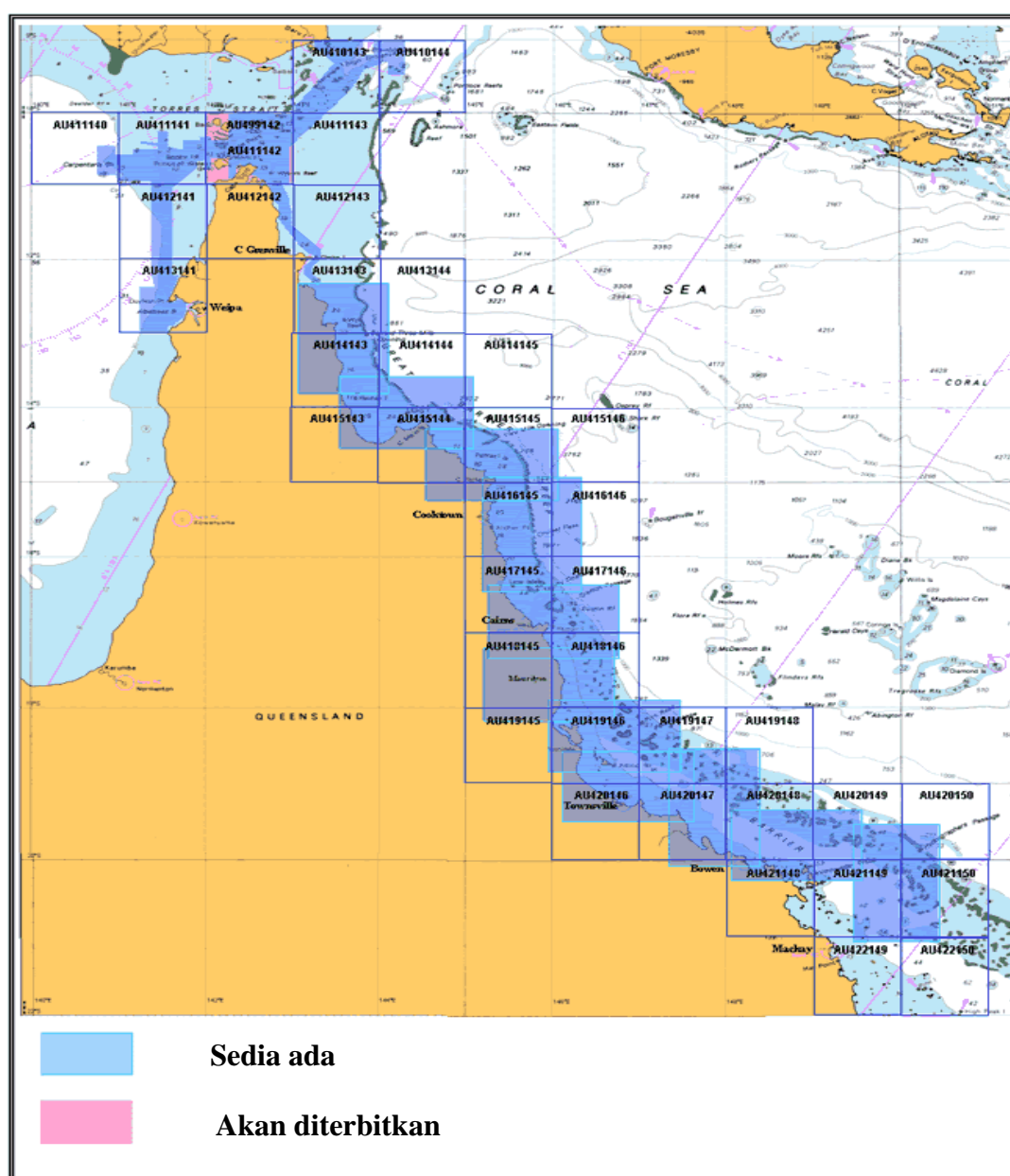
| Sel      | Title                       | Usage    | Edit<br>on | Publication<br>Date | Numbers of<br>Update |
|----------|-----------------------------|----------|------------|---------------------|----------------------|
| C25E0001 | Mirs Bay                    | Harbour  | 1          | 2 Jan 2004          | 0                    |
| C24E0002 | Tap Mun                     | Approach | 1          | 2 Jan 2004          | 0                    |
| C25E0003 | Tolo Harbour                | Harbour  | 1          | 2 Jan 2004          | 0                    |
| C24E0004 | High Island East            | Approach | 2          | 2 Jan 2004          | 1                    |
| C25E0005 | Sai Kung                    | Harbour  | 2          | 2 Jan 2004          | 2                    |
| C24E0006 | South Eastern<br>Approaches | Approach | 2          | 2 Jan 2004          | 2                    |
| C25C0007 | Harbour ;V<br>Central Part  | Harbour  | 2          | 2 Jan 2004          | 1                    |
| C25C0008 | Harbour ;V<br>Western Part  | Harbour  | 2          | 2 Jan 2004          | 1                    |
| C24C0009 | East Lamma                  | Approach | 2          | 2 Jan 2004          | 0                    |
| C24C0010 | West Lamma                  | Approach | 2          | 2 Jan 2004          | 1                    |

### 2.9.2 Example of ENC S-57 for Australia Area

In Australia, the first cell of ENC S-57 had published by Australian Hydrographic Service (AHS) and it is known as Seafarer® ENC. It is the electronic chart in vector format that developed by fulfilling IMO standard for uses in ECDIS. In order to fulfil the need of users, the area of Seafarer® ENC has divided to different types according to user requirement, as below:

- (i) For limitation of navigation area that sensitive to natural environment and main ports authorities.
- (ii) Main path of navigation.
- (iii) Entering and Exiting path around the ports.
- (iv) Area along the coast.

The main case that implemented by AHS is to complete the area nearly to 1000 nautical miles withing the Torress Strait and Great Barrier Reef (GBR). It included Great North East Channel, ports and other main navigational paths in that country. Collection of premiere Seafarer® ENC published on 1st July 2002 whereby it is the sel ENC for Great Barrier Reef from Weipa across the Torres Strait to Claremont Isles. Figure 2.7 shows the latest publication of ENC for the north area of Australia that contains the navigational path within Weipa Port at Carpentaria and Whitsunday Group bay in Great Barrier Reef area (<http://www.hydro.gov.au>).



**Figure 2.7:** Cell ENC S-57 for North of Australia

(Source: <http://www.hydro.gov.au/images/enc-availability.gif>)

### **2.9.3 Example of ENC S-57 for Italy Area**

There are two strategies that used to produce ENC S-57 for Italy, which are:

- (i) Temporary Paper Chart  
Implement the compilation of digital data through importing source of paper chart to the environment of ENC S-57.
- (ii) Old Paper Chart  
Using the digitization method on the old paper chart.

Therefore, the Italian Hydrographic Institute (IHI) launched a set of data compilation for the port chart and its surrounding area as shown in Figure 2.8. Other than that, development of Bathymetric Information System by IHI really helped much in the object data for S-57 compilation (e.g., beach line, contour, depth and others) so that it can be more accurate with the added information from the data surveying.



In 1st January 1997, IHI has launched Electronic Chart Division with the activity of first phase that focus on the study towards standard of specification S-57. Starting on March 1997, nearly 56 charts have chosen to be digitized and exchanged to ENC S-57 format version 3.0. To produce a set a quality data, effort are needed to optimized the process of data coding and cataloging to smooth the digitize operation from time to time. IHI still keep on study the softwares that able to used for updating data that can import or export in different format (e.g, DGN, DXF and ASCII). Till now, 120 set of ENC S-57 has succeeded published for Italy water area by IHI ([www.marina.difesa.it/idro/index.htm](http://www.marina.difesa.it/idro/index.htm)).

## **2.10 Roles of GIS in Hydrography**

Hydrographic GIS is an emerging utility, which not only promises effectiveness and speed in providing hydrographic products and services but can also provide much needed services to other emerging users of hydrographic and oceanographic data likes administrators, oceanographer and engineers. This GIS could be a backbone for ocean related data in the larger National Geospatial Data Infrastructure (NGDI) (Mittal, 2002).

There are a number of considerations that must be taken in order to improve a marine navigation (e.g. weather damage, tidal, water depth, machinery damages, harmful obstructions and so forth). With the existence of GIS technology, Hydrographic Information System (HIS) can integrate all the activities of a hydrographic office on a single integrated digital platform. In addition, it could be further integrated to oceanographic and topographical databases.

Besides, to enhance the safety of navigation, GIS has enabled hydrographic offices to discharge their roles effectively in the fields of delineation of maritime boundaries and also Coastal Zone Management (CZM).

The major usages of GIS in Hydrography are in processing of digital field data, preparation of electronic chart and paper navigational charts (Mittal, 2002). The electronic chart is usually used as a base map for oceanic/coastal GIS domain. The electronic chart provides an enabling tool for building a comprehensive GIS enabled database for the oceanic and coastal domain. It also provides a base-map for the sea.

Currently, the GIS trend is moving to Web environment and it does bring more benefits for hydrography particularly in managing the electronic chart in a cost effective way. The details of this topic will be discussed in more detail in Chapter 3, which is elaborating the Web environment and its use for nautical charting.

## **2.11 Conclusion**

From the literature, more and more nautical charts are now presented the electronic chart that can bring benefits to users. Some of the electronic charts can be used in an interactive way to help users in decision making and planning. Those electronic charts can be used in whether ECDIS, ECS and RCD as a compile system to assist user to obtain various of information in vessel navigation.

Furthermore, there are many types of mechanisms that can be used in producing electronic charts or ENC S-57, all publishers have to make sure the cells of ENC S-57 that produced are fulfilling with the standard specification of IHO. For the system and software developer for ECDIS, they must obey all the standard specification that set by IHO, IMO and IEC. Based on the literature, HO of each country responsible in the producing ENC S-57 for water area. However, the effect of the problems that

have stated above has led the producing of ENC S-57 able to published by some companies that chosen by IHO to smooth the rate of publishing in the world.

The evolution of technology in nautical charting has helped researcher in the data collection. Therefore, it is possible for the researcher to obtain the latest nautical charts and also the Notice to Mariners in order to yield the application that contains latest information. However, the electronic chart is quite costly in the market, thus resarcher needs to digitize the latest paper charts from RMN into the digital format for application uses.

## **CHAPTER 3**

### **DATABASE DESIGN**

#### **3.1 Background**

In order to build an application successfully, it is important for researcher to focus on the database design before the system creation. Database design is to define the needs of end user for the application in order to arrange the relevance information into it.

It will determine the contents and also the final result of the application. Therefore, this chapter will explain in detail regarding to the procedures of database design for the research.

#### **3.2 Need Assessment**

Generally, there are three kinds of tasks included in need assesment, which are need of market, need of users and need of system. However, researcher will focus



on need of users because the end result of the study will not be shown in the existing market. One of the purposes to run the need of users is to ensure the real information that really needed to a system or database.

Researcher needs to do a user need assessment for the related parties (e.g. Port Authorities and Marine Departments). The purpose of the need assessment is to ensure the information in the research fulfill the need of users. Furthermore, a well organised user needs assessment result in a well-presented structural database, with query and storage supported. The list of port authorities that given questionnaires are:

- (i) Marine Department of Middle Region
- (ii) Marine Department of Eastern Region
- (iii) Marine Department of Northern Region
- (iv) Marine Department of Southern Region
- (v) Marine Department of Sabah
- (vi) Marine Department of Sarawak
- (vii) Tanjung Pelepas Port
- (viii) Sabah Port
- (ix) Pasir Gudang Port
- (x) Terminal FerryTanjung Belungkor
- (xi) Bintulu Port
- (xii) Kuantan Port
- (xiii) Pulau Pinang Port
- (xiv) Klang Multi-Terminal
- (xv) Port Dickson Port
- (xvi) Melaka Port
- (xvii) Pulau Tioman Port
- (xviii) Kuantan Port
- (xix) Kuala Kedah Port
- (xx) Kuala Perlis Port
- (xxi) Pangkalan Kubor Port
- (xxii) Pangkor Port
- (xxiii) Kuah Port
- (xxiv) Lumut Port

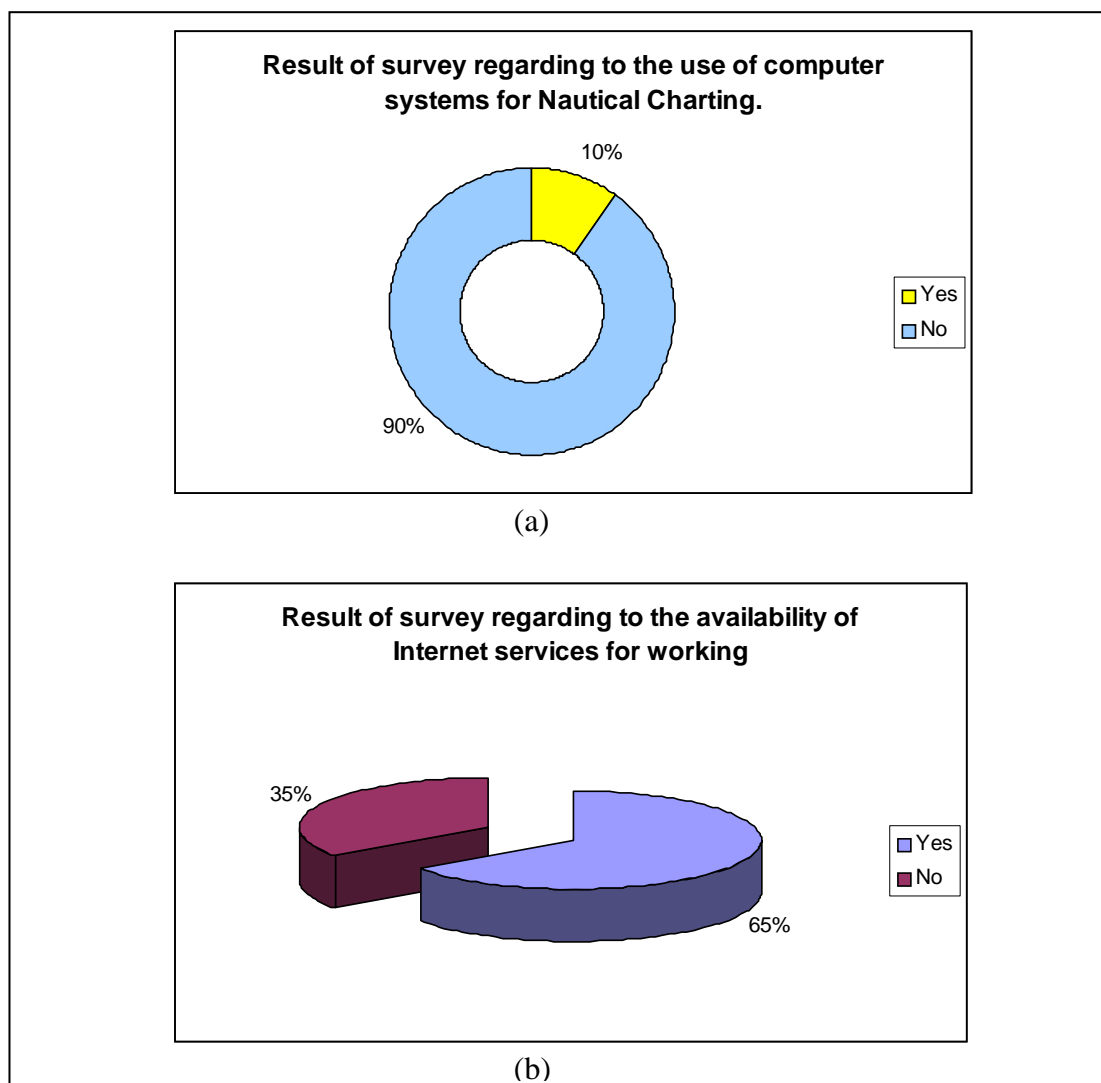
- (xxv) Muar Port
- (xxvi) Mersing Port
- (xxvii) Teluk Intan Port
- (xxviii) Tanjung Lembong Port
- (xxix) Kerteh Port
- (xxx) Sungai Rengit Port
- (xxxi) Kukup Port
- (xxxii) Tanjung Pengelih Port
- (xxxiii) Tanjung Gemok Port
- (xxxiv) Kuala Besut Port
- (xxxv) Kemaman Port

For this research, around 36 copies of questionnaires have been distributed to both staffs at Port Authorities and Marine Departments in Malaysia. The purpose of this distribution is to obtain and understand the related information and their opinions toward to the low cost digital nautical charting for small boats and leisure crafts in Malaysia and Nautical – WebGIS application that would be developed. The example set of questionnaires that have been created for need assessment is shown in the **Appendix B**. In addition, the needed functions, data spatial and data attribute also would be comprehended through the result of survey.

By referring to the result of the respond from related parties, there are some main difficulties related with the vessel navigation activity that caused by several factors as below:

- (i) Problems in entering and exiting of vessel at port authorities that nearby fishing activities.
- (ii) Lack of modern navigational tools for small boats.
- (iii) Unclear sight towards lighthouse signal particularly when fog occurred.
- (iv) Shallowness water area at certain jetty.
- (v) Lack of statutory knowledge in navigation among fishermen, boat and craft users.

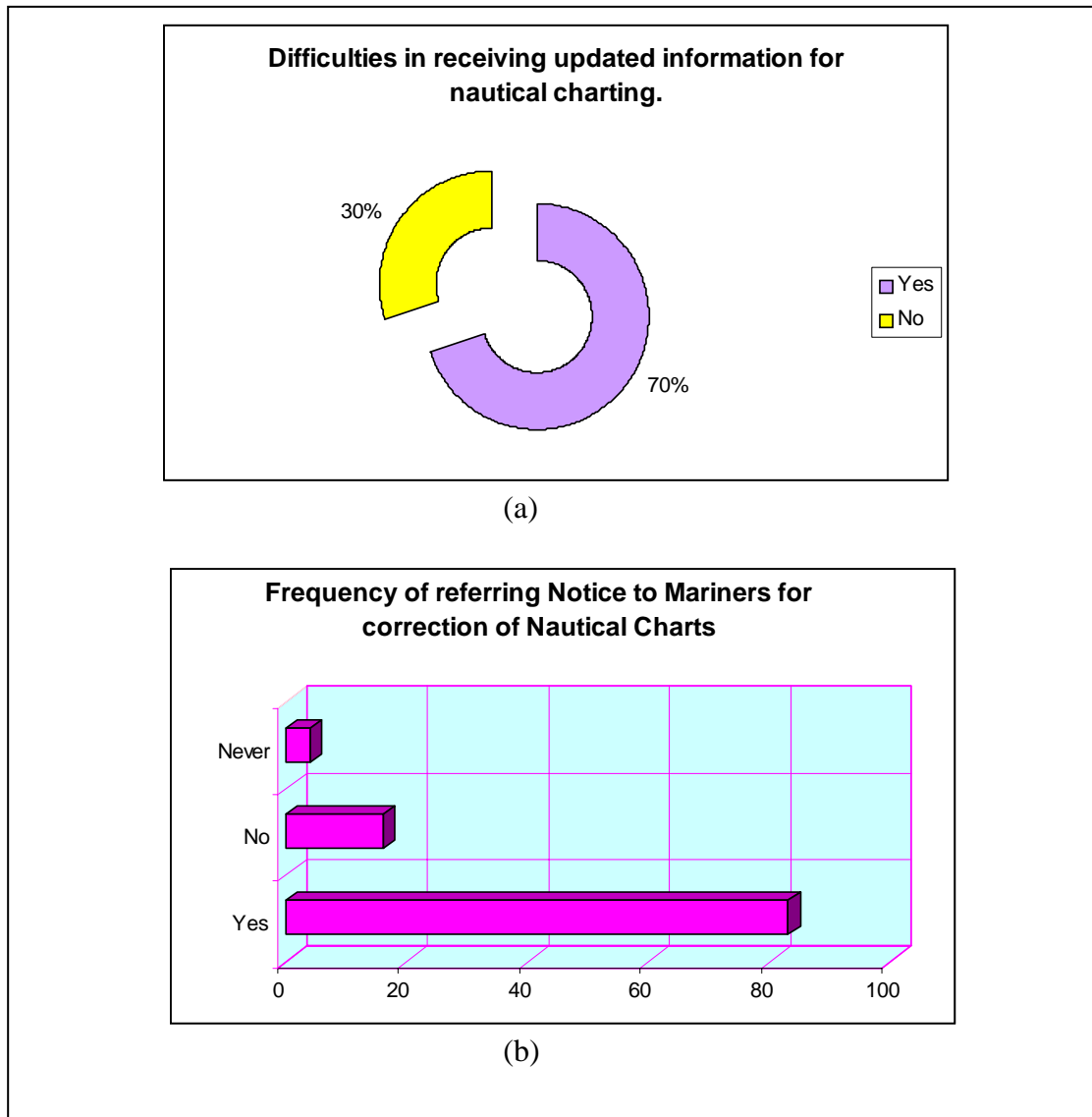
In addition, all of the nautical charts in the market are still in hardcopy but are some of the charts already tendered by C-MAP Malaysia Sdn. Bhd to convert into ENC format. In these related parties, most of the staffs are facing some problems like lack of staffs and specialists, late update for nautical charts and improper data management (see Figure 3.1). From the Figure 3.1(a), it is obvious that most staffs are still using convensional method to manage the information. And, most of the departments have the availabilities of Internet for staff (see Figure 3.1(b)). Therefore, it is suitable for them to have a proper Web application for publishing the Malaysia nautical charts in order to enhance the working performance. Other than that, the data dissemination of nautical charts also can be achieved.



**Figure 3.1:** Result of survey for (a) the use of computer system for Nautical Charting and (b) Availability of Internet services for working

In the other hand, the results of opinion from related parties also had shown improper management of the notice to mariners. Although the latest notice to mariners would also update in marine department official website, however the Notice to Mariners are shown in Adobe Portable Document Format (PDF). Therefore, users need to draft the position of the happening in their paper charts and it is a time consuming problems. Moreover, the total sheets of notice to mariners would not be updated into the paper charts annually due to the late updating of the nautical charts from RMN. According to Figure 3.2 (a), about 70% of responders agree with the problems in receiving updated information for charts. And, more than

80% of responders would always look into notices to mariners for corrections of nautical charts. Thus, it is necessary to launch the Nautical – WebGIS to solve the current difficulties.



**Figure 3.2:** Result of survey for (a) Difficulties in receiving updated information for nautical charts and (b) Frequency of referring notice to mariners for correction of nautical charts.

The result of survey has been proved that there is no Web application for nautical charts available in Malaysia, therefore this research will be a pioneering in improving the working performance in both organizations and other related parties through Web. From the comment and opinion that have been collected, researcher

understood clearer regarding to the information that should be in Nautical – WebGIS. Some Information that is logically to be presented is as below:

- (i) The presentation of chart should be in grid-based coordinates, which is RSO due to the analysis must be established in meter unit. Thus, the presentation for geography coordinates would also show up in readable format. For the Malaysia Charts information, some of the needed field names are scales, minimum and maximum geographic coordinates, code, date of production, date of edition, projection and others.
- (ii) Other informations that presented on chart like sounding, nature, offshore installation, water area, swaping area and others also needed to be kept in different table with related field names.
- (iii) Information for notice to mariners should include coordinates, happening, charts affected, position and date of notice.
- (iv) For the spatial presentation, most of the layers should able to be selectable and some of the less important layers such as nature and text would be in readable only.
- (v) Query of information based on code of Malaysia charts and Notice to Mariners are compulsory.
- (vi) The reference for symbols and abbreviations that publish in MAL 1 should be published on web.

### **3.3 Database Design**

The database design is considered as an important phase to determine the content of the application. The needs of user have to be defined before designing the database structure. The database design phrase is aim to clarify the features of data that are necessary to form the database modeling. In this phase, there are some steps

are needed to be focused such as conceptual design, logical design and physical design.

### 3.3.1 Conceptual Design

The conceptual design includes all the required data that would be used for system analysis. It shows the relationship between data elements in an Entity Relationship Diagram (ER Diagram) and normalization. Furthermore, it certified the data modeling in order to classify the database design. (Rob, 1997)


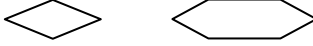

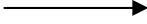
From the information that obtained from user need assessment, entities that involved in the development of database for digital navigational charting for small boats and leisure crafts have been defined in Table 3.1. Those classifications of entities are referring to the information in MAL 1 – Symbolization and Abbreviation for Malaysian Navigational Charts. (TLDM, 1997)

**Table 3.1:** Entities of Digital Navigational Charts (Malay Versions)

|                                 | Entiti-entiti  |
|---------------------------------|--|
| <b>HIDROGRAFI</b>               | Kedalaman, Bahaya, Perahu_Layar, Laluan_harungan, Kaw_batas, Pemasangan_Luarpesisir, Arus_dan_ps |
| <b>TOPOGRAFI</b>                | Semulajadi, Buatan, Mercutanda, Pelabuhan  |
| <b>BANTUAN DAN PERKHIDMATAN</b> | Stesen_isyarat, Kem_perahulayar, Marina, Bantuan   |
| <b>AM</b>                       | Metada (Tarikh_tahun_keluar, Negara, Tarikh_Ukuran, Unjuran, Judul, NO_carta)                    |

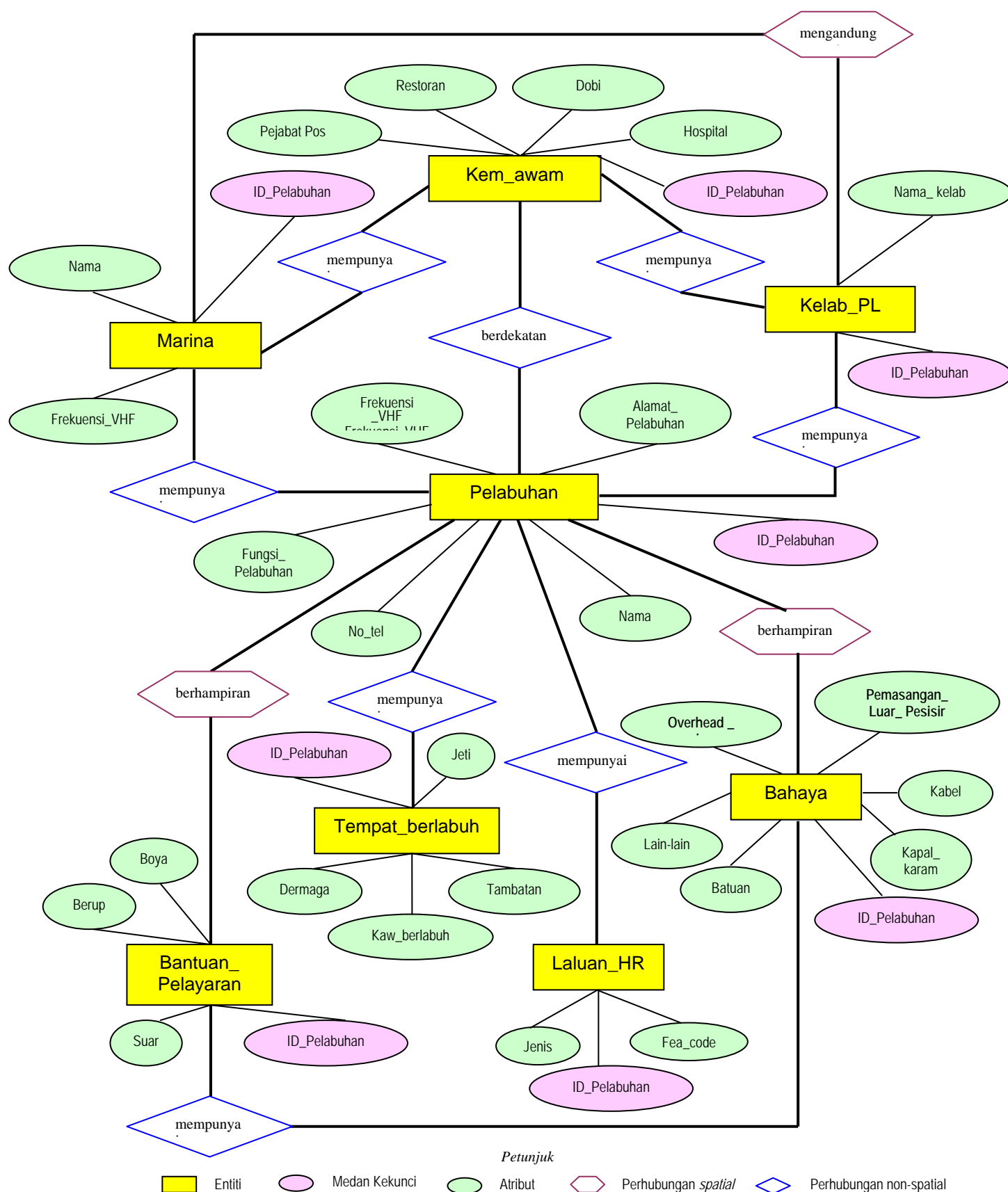
Explanation of design symbol is shown in Table 3.2

**Table 3.2:** Example of Represented Model ER Conceptual

| Concept      | Represented Symbol   |
|--------------|--|
| Entity       |   |
| Relationship |  |
| Attribute    |   |
| Subset       |   |

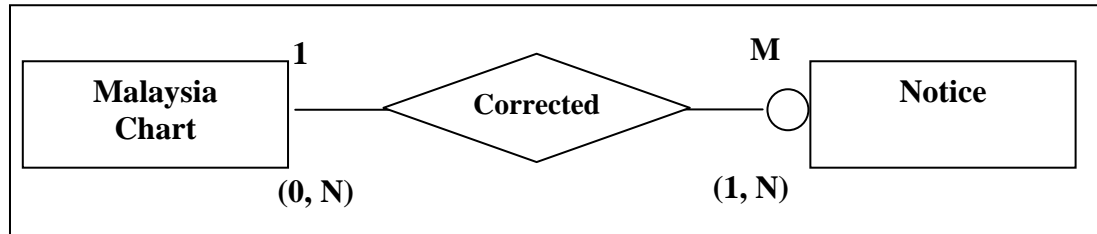
The model conceptual for the first phase of the research is shown in Figure 3.3. There are eight main entities involved, which are *kemudahan awam*, *kelab perahu layar*, *marina*, *pelabuhan*, *tempat berlabuh*, *bahaya*, *bantuan pelayaran serta laluan* and *harungan* in that design. All of the entities fulfill the need of vessel navigational needs for small boats and leisure crafts in Malaysia.





**Figure 3.3:** Relational entities for the development of database for digital nautical charts. (Malay versions)

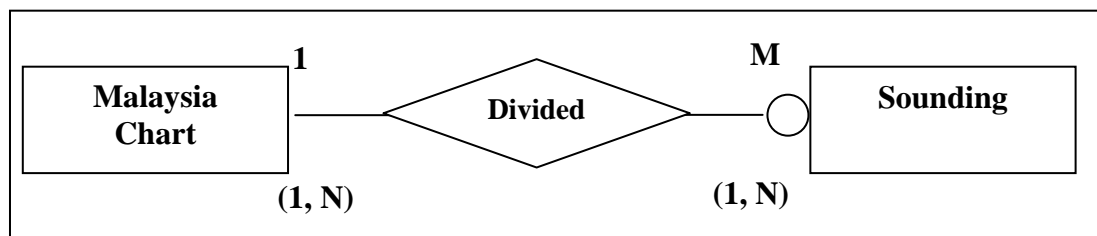
For the second phase of this research, some business rules for the main data elements in the research are formed.



**Figure 3.4:** Business rules for entity Malaysia Chart and entity Notice

Based on Figure 3.4, the relationship between Malaysia Chart and Notice is :

- (i) A Malaysia Chart can have none of the Notice or it can be many Notices.
- (ii) A Notice would minimum affected a Malaysia Chart or it can be affected a series of Malaysia charts.



**Figure 3.5:** Business rules for entity Malaysia Chart and entity Sounding

Refer to Figure 3.5, the relationship between entity Malaysia chart and entity sounding is:

- (i) A Malaysia chart would minimum consist a sounding point or it can be consist many sounding point.
- (ii) A Sounding may only record in a Malaysia chart or many Malaysia charts.

### 3.3.2 Logical Design

In this stage, the conceptual design that had been created previously would convert into the internal modeling for a database management system such as Access, Oracle or others. The relational database modeling has become a choice in the development of current database because of its support the relationship of data) eg: 1:1, 1:M and M: N) that exist in database system. Besides, it also enable query for searching related information.

Other than that, the structure of tables, indices and description also designed in this stage. The table below shows the detail of entities and also attributes for the development of digital navigational charting as a reference for this study (Table 3.3). For the second phase in this study, the data has been expanded, thus there is another example of details for the Malaysia charts table is shown in Table 3.4.

**Table 3.3:** Detail of entities and attribute (Malays versions)

| <b>Nama medan</b> | <b>Atribut</b>            | <b>Jenis data</b> | <b>Bentuk Data</b> |
|-------------------|---------------------------|-------------------|--------------------|
| Kedalaman         | Nilai_kedalaman (Z)       | INT(4)            | <i>Point</i>       |
|                   | Lokasi_spatial (X,Y)      | INT(6,6)          | <i>Point</i>       |
|                   | Fea_code                  | CHAR(6)           |                    |
|                   | Jenis_kedalaman           | CHAR(1)           |                    |
|                   | <u>Had_kedalaman</u> (PK) | CHAR(6)           | <i>Polygon</i>     |
| Bahaya            | <u>Id_bahaya</u> (PK)     | CHAR(4)           |                    |
|                   | <u>Had_kedalaman</u> (FK) |                   |                    |
|                   | Jenis_bahaya              | INT(1)            |                    |
|                   | Fea_code                  | CHAR(6)           |                    |
|                   | Lokasi_spatial            | INT(6,6)          | <b>Point</b>       |
| Kelab_PL          | <u>Id_Kelab</u> (PK)      | CHAR(6)           |                    |
|                   | Nama                      |                   |                    |

|                 |  |   |                                       |
|-----------------|--|---|---------------------------------------|
|                 | Alamat<br>NO_Tel<br>Lokasi_spatial   | CHAR(50)<br>CHAR(150)<br>INT(10)<br>INT(6,6)  | <i>Point</i>                          |
| Kem_awam        | <u><b>Id_Kemawam(PK)</b></u><br>Jenis_Kemawam<br>Fea_code<br>Lokasi_spatial  | CHAR(4)<br>INT(1)<br>CHAR(4)<br>INT(6,6)  | <b>Point</b>                          |
| Marina          | <u><b>Id_Marina(PK)</b></u><br><u>Id_Kemawam(FK)</u><br>Nama_marina<br>Frekuensi_VHF<br>Tahun_bina<br>NO_Tel<br>Alamat<br>Fea_code<br>Lokasi_spatial | CHAR(4)<br><br>CHAR(14)<br>INT(10)<br>INT(1)<br>INT(10)<br>INT(60)<br>CHAR(4)<br>INT(6,6) | <i>Point</i>                          |
| Pelabuhan       | <u><b>Id_Pelabuhan(PK)</b></u><br>Nama_Pelabuhan<br>Frekuensi_VHF<br>Jenis_Pelabuhan<br>NO_Tel<br>Fea_code<br>Lokasi_spatial                         | CHAR(4)<br>CHAR(14)<br>INT(10)<br>INT(1)<br>INT(10)<br>CHAR(4)<br>INT(6,6)                | <i>Point</i>                          |
| Laluan_harungan | <u><b>Id_LH (PK)</b></u><br>Fea_code<br>Jenis_LH<br><u>Had_kedalaman(FK)</u>   | CHAR(4)<br>CHAR(6)<br>INT(1)<br>CHAR(6)   | <i>Line</i><br><br><br><i>Polygon</i> |

**Table 3.4:** Table structure design for the entity Malaysia Charts in the logical design phase

| Table Name      | Attribute Name | Description          | Type of Data | Decimal | Size of Field Name | Format        |
|-----------------|----------------|----------------------|--------------|---------|--------------------|---------------|
| Malaysia charts | ID             | ID for charts        | Text         |         | 13                 | X(13)         |
|                 | Code           | Code for charts      | Text         |         | 10                 | X(10)         |
|                 | Scale          | Scale                | Text         |         | 15                 | X(15)         |
|                 | State          | State for charts     | Text         |         | 20                 | X(20)         |
|                 | Name           | Charts name          | Text         |         | 150                | X(150)        |
|                 | P_Note         | Publication Note     | Text         |         | 20                 | X(20)         |
|                 | E_Note         | Edition Note         | Text         |         | 20                 | X(20)         |
|                 | G_Location     | Geographic Location  | Text         |         | 50                 | X(50)         |
|                 | Projection     | Charts Projection    | Text         |         | 30                 | X(30)         |
|                 | H_Datum        | Horizontal Datum     | Text         |         | 10                 | X(10)         |
|                 | V_Datum        | Vertical Datum       | Text         |         | 10                 | X(10)         |
|                 | D_Unit         | Depth Units          | Text         |         | 10                 | X(10)         |
|                 | H_Unit         | Height Units         | Text         |         | 10                 | X(10)         |
|                 | Max Y          | Maximum Coordinate Y | Number       | 6       |                    | 999999.999999 |
|                 | Max X          | Maximum Coordinate X | Number       | 6       |                    | 999999.999999 |
|                 | Min Y          | Minimum Coordinate Y | Number       | 6       |                    | 999999.999999 |
|                 | Min X          | Minimum Coordinate X | Number       | 6       |                    | 999999.999999 |

### 3.3.3 Physical Design

Physical design is the stage to define the storage and accessible of data for optimizing the database performance. The limitation of speed, harddisc space, period of response and others would be confirmed. The improper design of this stage will consequently influence the location of data and the performance of overall system. In the second phase of this research, the total storage of data for developing the database is shown in Table 4.4.

**Table 4.4:** Summary of Storage data for the Research Database (2<sup>nd</sup> phase)

| Table Name            | Storage of Table (KB) |
|-----------------------|-----------------------|
| Malaysia Charts       | 43.5                  |
| Notices               | 70                    |
| Shore                 | 14                    |
| Water Area            | 61                    |
| Sounding              | 76                    |
| Offshore Installation | 12                    |
| Lights                | 17                    |
| Obstruction           | 58                    |
| Nature                | 6                     |
| Mercator              | 8                     |
| Mercator Label        | 1                     |
| Swamping              | 15                    |
| Track                 | 1                     |
| Services              | 1                     |
| Radio Radar           | 4                     |
| Limit Area            | 2                     |
| <b>Total</b>          | <b>413.5</b>          |

### 3.3.4 Example in Query Planning

Within the analysing query that can be done through the Structured Query Language (SQL) from this database are as below:

```
SELECT (*) FROM (nama jadual entiti) WHERE (medan)
```

The purpose is to find the spatial location that related with the specific information in. Thus, user can do some queries on the specific information in the database as below:

If user question is:

Where are the depth area that less than 5M in the navigational path?

SQL Query1:

```
SELECT (*) FROM (kedalaman) WHERE (kedalaman_dilaluanlayar <5m)
```

If user question is:

Where are the dangerous rocks located in MAL5622?

SQL Query2:

```
SELECT (*) FROM (bahaya) WHERE (jenis_bahaya=batuan)
```

If user question is:

Where are the ports in MAL5622?

SQL Query3:

```
SELECT (*) FROM (tempat_berlabuh) WHERE (nama_pelabuhan)
```

### **3.4 Conclusion**

At the beginning of database design, questionnaires are designed and sent to related parties. Fortunately, most of the questionnaires are able to be received back from them and this helps to analyse the user requirement for the research to be developed. In general, the process of database design for both phases in this study has fulfilled the criteria of database development as the researcher has gone through the design for model conceptual, model logical and physical directly.

The relationships between the data spatial have been defined during the conceptual design. And, most of the relationships between the data are 1: M such as the relationship between Malaysian Charts and sounding or offshore installation. In logical design, the format and type of attribute data to be kept in each table in the database have been designed. Those data attributes for the study have been kept in Microsoft Excel. In addition, 413.5KB storage of the database also has been estimated in the physical design of the second phase in this research.



## CHAPTER 4

## PHASE I - VECTOR DATA PREPARATION USING CARIS GIS 4.4a

## 4.1 Background

As we know, CARIS GIS 4.4a prepares a lot of interactive programs such as CARIS Editor, SAMI, Information Manager, Image Mosaic, V3D, Plot Composer, Database Manager, Setup, Report and DDE Interface for users. Each program might has same or different functions regarding to the aspect of application and related references that can be reached through CARIS Help or CARIS Users Guide and Tutorials (Figure 4.1). Other than that, understanding about the structure file CARIS (\*.des) and other files that related also needed to be focus because the data kept into the CARIS file needs some interactive files to support the presentation of data effectively.



**Figure 4.1:** Panel icon for CARIS GIS 4.4a

## 4.2 Structure File of CARIS

CARIS File included 12 components file that keep data using same file name but different extensions. Those component files that form structure file of CARIS are shown in Table 4.1 and they are all in binary code except note and record.

**Table 4.1:** Main components in CARIS file

| Extension | Type of File  | Description                         |
|-----------|---------------|-------------------------------------|
| .cel      | Cell          | Spatial query                       |
| .des      | Descriptor    | Identity data of CARIS              |
| .dta      | Node          | Coordinate data X, Y, Z             |
| .not      | Note          | Text                                |
| .ras      | Raster        | Raster data                         |
| .lin      | Line          | Polyline data                       |
| .nol      | Node          | Point data                          |
| .pol      | Polygon       | Polygon data                        |
| .idx      | Index         | Record index for feature data       |
| .ix       | Working Index | Related with above index            |
| .rec      | Record        | Record file for each program in run |
| .ntx      | Interchange   | Exchange file format in CARIS       |

When user is using different data processing operation in CARIS, some of the additional component file might be used as shown in Table 4.2.

**Table 4.2:** Additional components file in CARIS GIS 4.4a

| Extension | Type of File         | Description                               |
|-----------|----------------------|---|
| .col      | Colour Table         | Text file that define colour for features |
| .con      | Control              | Text file for registration in CARIS file  |
| .d_0      | Display (visibility) | Parameter menu that can be seen           |

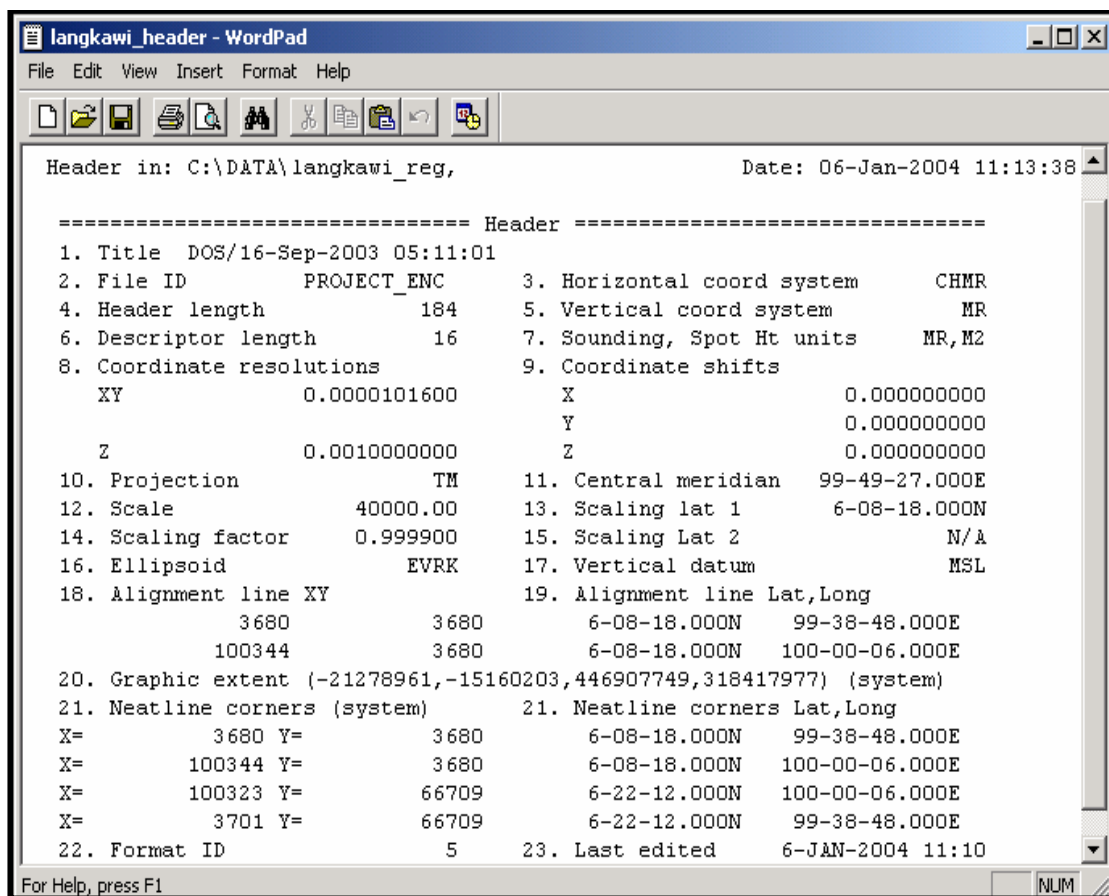
|      |                     |  |
|------|---------------------|--|
|      | parameters          |  |
| .err | error message       | Text file that keep topology error                           |
| .ntb | Network Topology    | Text log that produce network topology                       |
| .plb | Polygon Topology    | Text log that produce polygon topology                       |
| .cla | DTM Class           | Text file that define colour for DTM (Digital Terrain Model) |
| .dcl | DTM Cell            | Improve the processing speed for DTM file                    |
| .tri | DTM Triangle Vertex | Keep vertex information for triangular of DTM                |
| .tvx | DTM Triangle        | Keep information for triangular of DTM                       |

#### 4.2.1 Creation of Header File

Basically, a CARIS file has 2 sections; there are header and data. Header has the geographic reference information that needed for data source. Normally, header will keep the these records:

- (i) Digital chart or map name
- (ii) Horizontal coordinate system
- (iii) Parameter for map transformation
- (iv) Ellipsoid reference
- (v) Map scale
- (vi) Resolution of coordinate (horizontal and vertical)
- (vii) Text and graphic

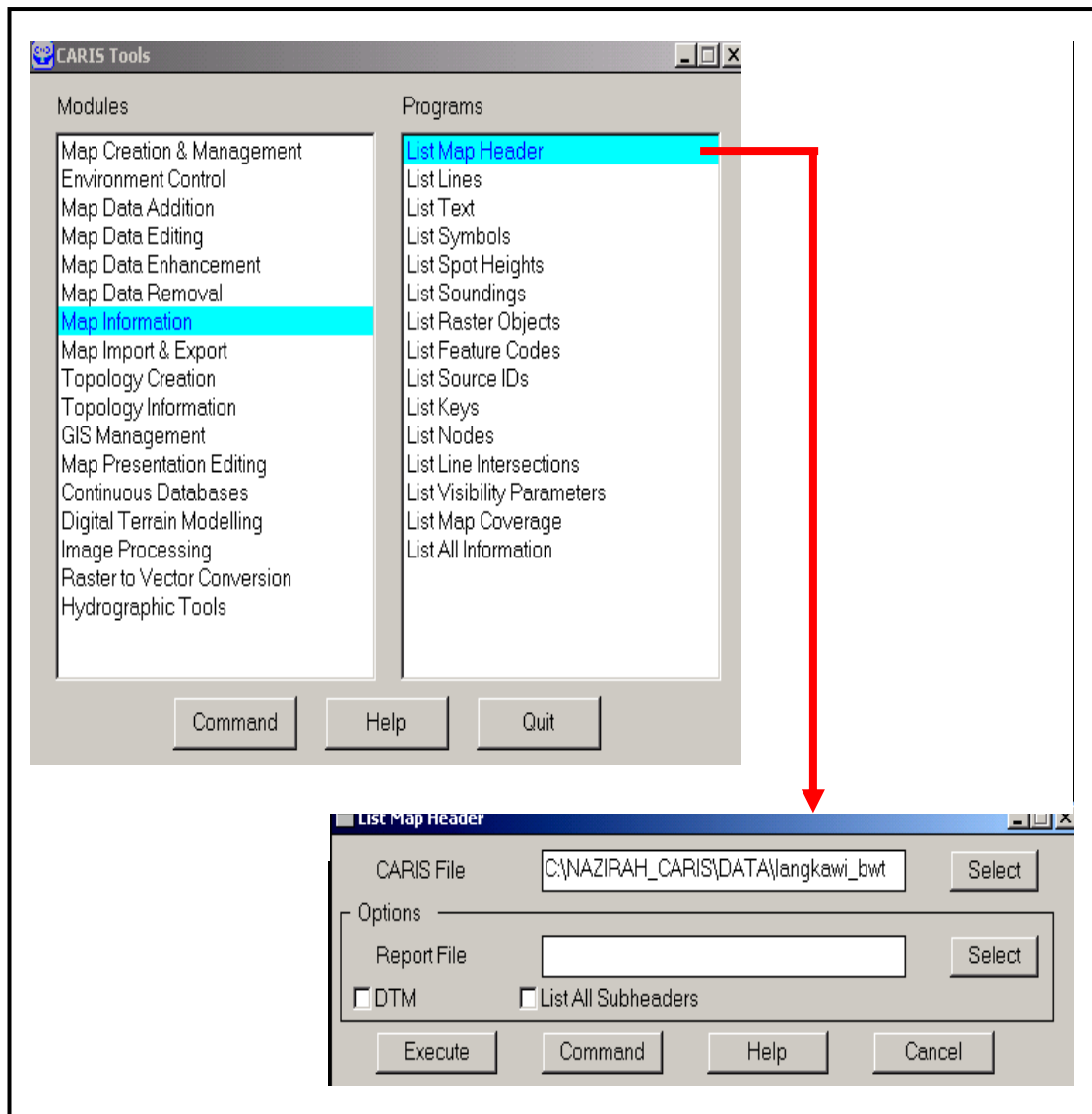
Source data for header can be obtained from the map reference or publication. Those information need to be recorded before a CARIS file prepared. Example of header file for this study is shown in Figure 4. 2.



**Figure 4.2:** Header file for this study

#### 4.3.1 Checking of Header File

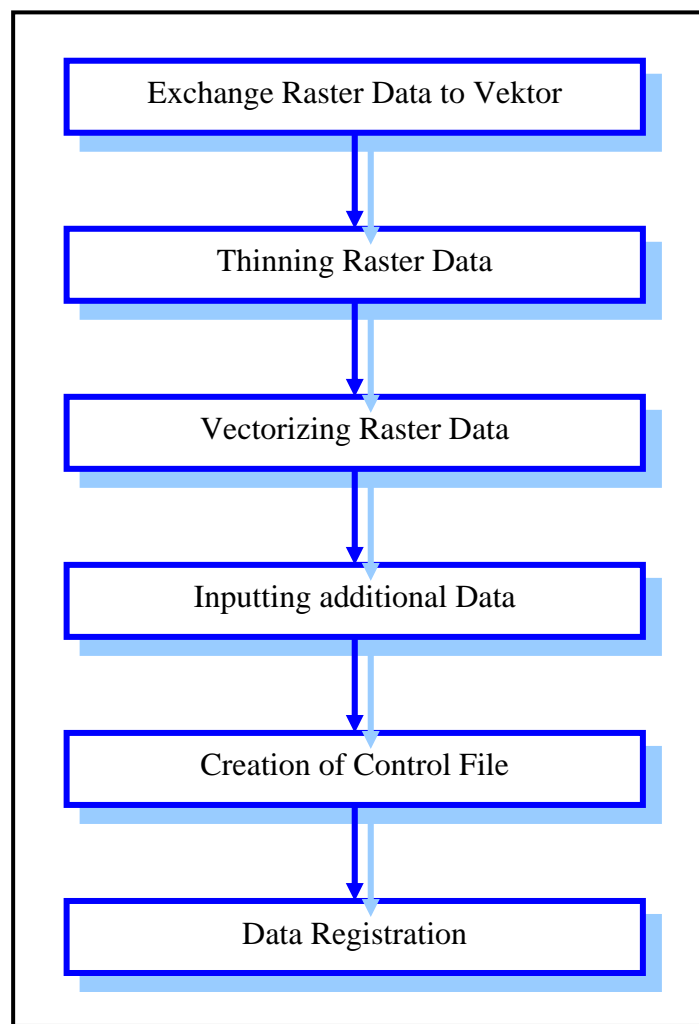
The checking or correction of information in header file can be done using CARIS Tools module through *Map Information > List Map Header* (Figure 4.3). Users need to fill in the empty space that shown in CARIS file and click on *Execute* button after finished. Later, the header file will be kept in text format as shown in Figure 4.2.



**Figure 4.3:** Method of checking header file

### 4.3 Preparation of Data Using CARIS SAMI

To produce a digital nautical chart, CARIS SAMI is needed, whereby the main objective is to convert the image from raster to vector. In short, the procedures are shown in Figure 4.4. CARIS SAMI only support TIFF image for data conversion.



**Figure 4.4:** Flow Chart to convert raster data to vector data using CARIS SAMI

Other than that, the main functions of CARIS SAMI are as below:

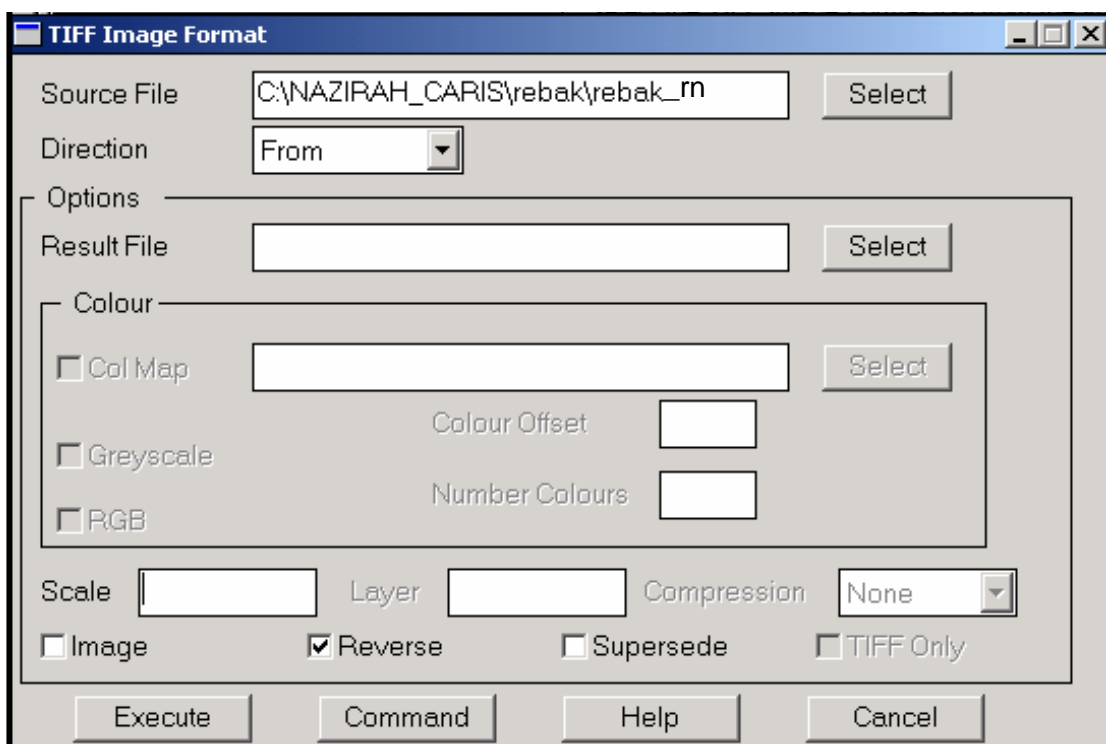
- (i) Enable data input with a screen image as background.
- (ii) Vectorise the polylines effectively in semi-automatic.
- (iii) On-screen digitising.
- (iv) Editing feature.
- (v) Printing.
- (vi) Customisation of menu, macros and icon.
- (vii) Online help provided.
- (viii) Conversion of data format.

### 4.3.1 Data Conversion (Raster to Vector)

In CARIS SAMI, users able on-screen digitising and converting data in semi-automatic way. There are three main process has been went through in this study for data conversion, such as:

- (i) Scanning Chart into TIFF format.
- (ii) Converting TIFF to CARIS raster data.
- (iii) Implement thinning using CARIS SAMI.

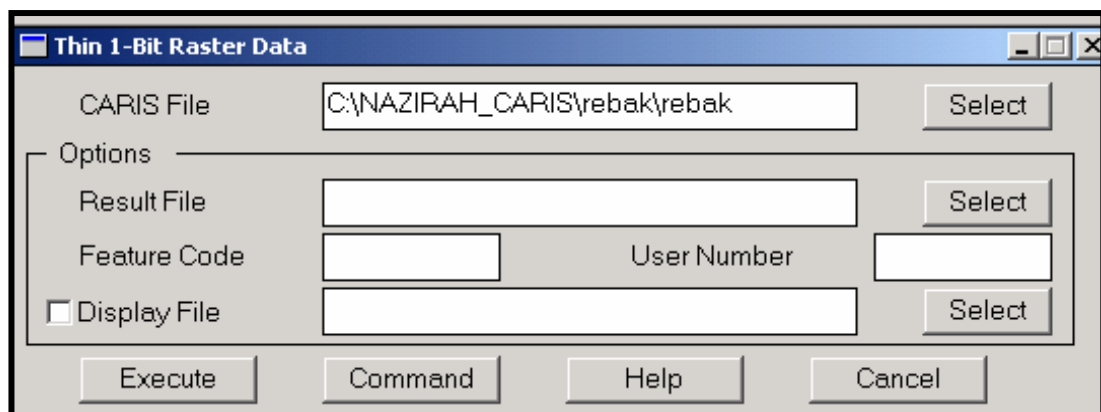
After the scanning process, it is needed to convert the TIFF file into a file that can be read in CARIS. In CARIS Tools, there is a menu named TIFF Image Format to convert TIFF black and white (1 byte per pixel) into CARIS raster object. Other than that, TIFF Image Format also can convert colour image into CARIS raster image (\*.ipv). The procedures are shown in Figure 4.5. In this study, TIFF file for MAL 5622 has saved as rebak\_rn.tif in Source File. Then, REFOTIFF is used for the process to convert TIFF image into CARIS file.



**Figure 4.5:** Converting TIFF Image into CARIS Raster Object

### 4.3.2 Thinning Raster Data

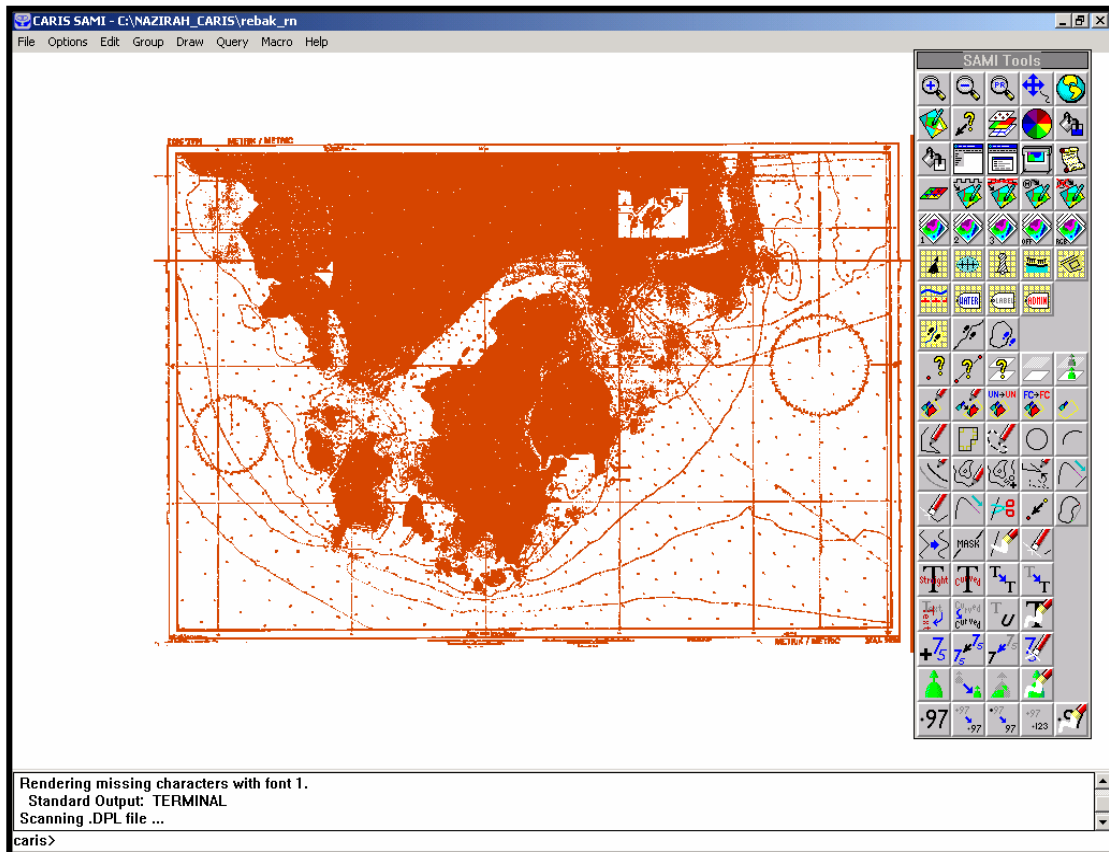
Thinning can be done through *Raster to Vector > Thin 1 Bit Raster Data* in CARIS Tools as shown in Figure 4.6. Process of thinning can be viewed **Appendix C**. It produced a new layer for the raster object in the CARIS file without changing the original image. Thin 1–Bit Raster Data is an interactive process named THINRAST.



**Figure 4.6:** Thinning for Raster Data

In this study, raster image that has went through the thinning process as shown in Figure 4.7 and Source Identifier for its has named as THINRAST.





**Figure 4.7:** Image of THINRAST

### 4.3.3 Semi-automatic of Vectorising

There are two ways to produce vector data in semi-automatic, which are:

- (i) *Edit > Line > Add > Line Follow*
- (ii) *Edit > Line > Add > Contour Follow*

During the vectorisation, data input can be done using *Edit* menu in CARIS SAMI. Symbols that included in this study are based on hydrographic symbols and information of vessel navigation. It has been classified as below:

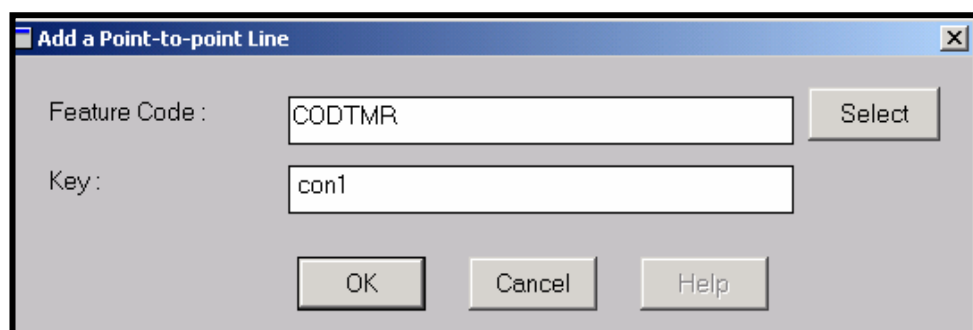
- (i) Icon panel for water area (fishing port, dangerous rocks, platform, limited fishing area and others).

- (ii) Icon panel for IALA (buoy, light house, sectional lines, navigational lines and others).
- (iii) Icon panel for land (triangulation points, airports, buildings, offices and others).
- (iv) Icon panel for coastlines (coastlines that had surveyed, jetty, river, coastlines that had not surveyed and others).
- (v) Icon panel for landlines (contour, road, railway, bridge and others).
- (vi) Icon panel for waterlines (dangerous lines, area that had not surveyed, cable area, limited area, depth contour and others).

#### 4.3.4 Inputting Additional data

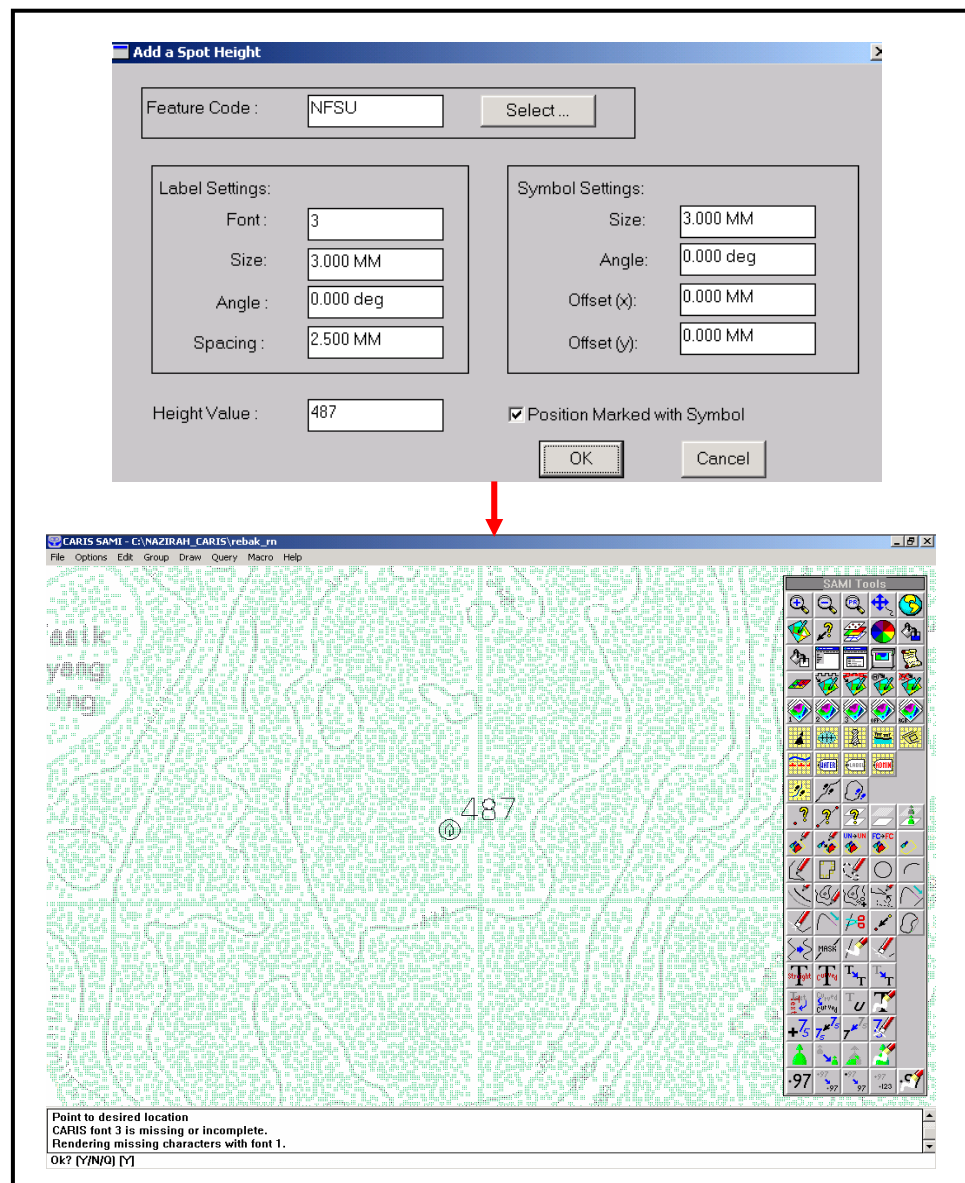
There are several methods to input feature data into the CARIS file. Features that included in the process of producing vector chart can be classified into polylines, depth value, height points, symbols and texts.

For the input of polylines, it can be reached through menu *Edit > Line > Add > Point-to-point* in CARIS SAMI as shown in Figure 4.8 and the result of digitisation for all data in the form of polylines are shown in **Appendix D**.



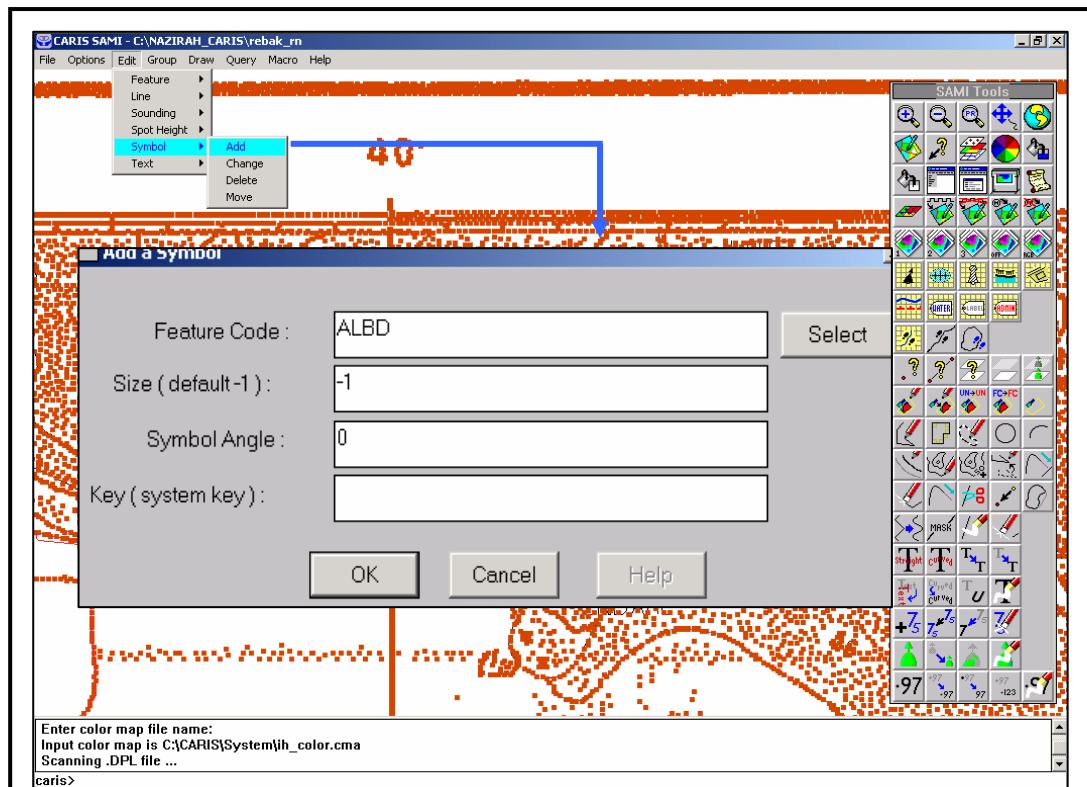
**Figure 4.8:** Inputting Polyline using *Add a Point-to-point Line*

In CARIS SAMI, height points can be inputted using menu *Edit > Spot Height > Add* as shown in Figure 4.9 or shortcut menu on SAMI Tools panel icon.

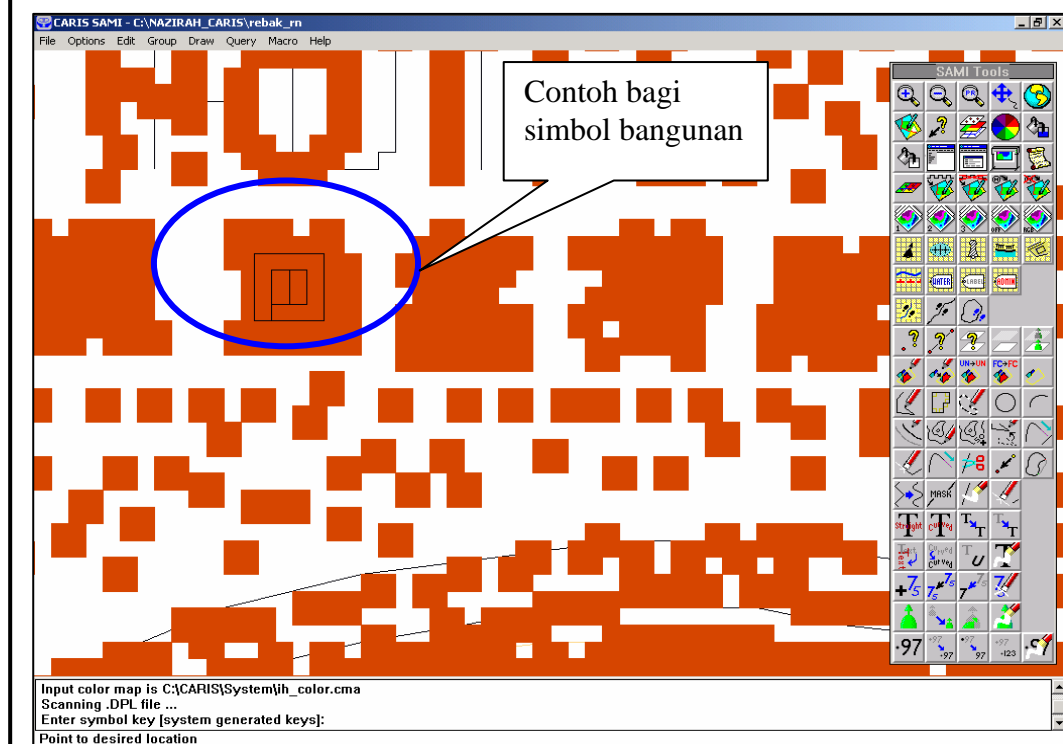


**Figure 4.9:** Inputting Height Pints using *Add a Spot Height*

Both of the symbol and text can be done in CARIS SAMI or CARIS Editor. Inputting symbol in CARIS can be reached through menu *Edit > Symbol > Add* (Figure 4.10). However, the inputting text as shown in Figure 4.11 can be done using menu *Edit > Text > Add > Straight* (or Along a Curve and From File).

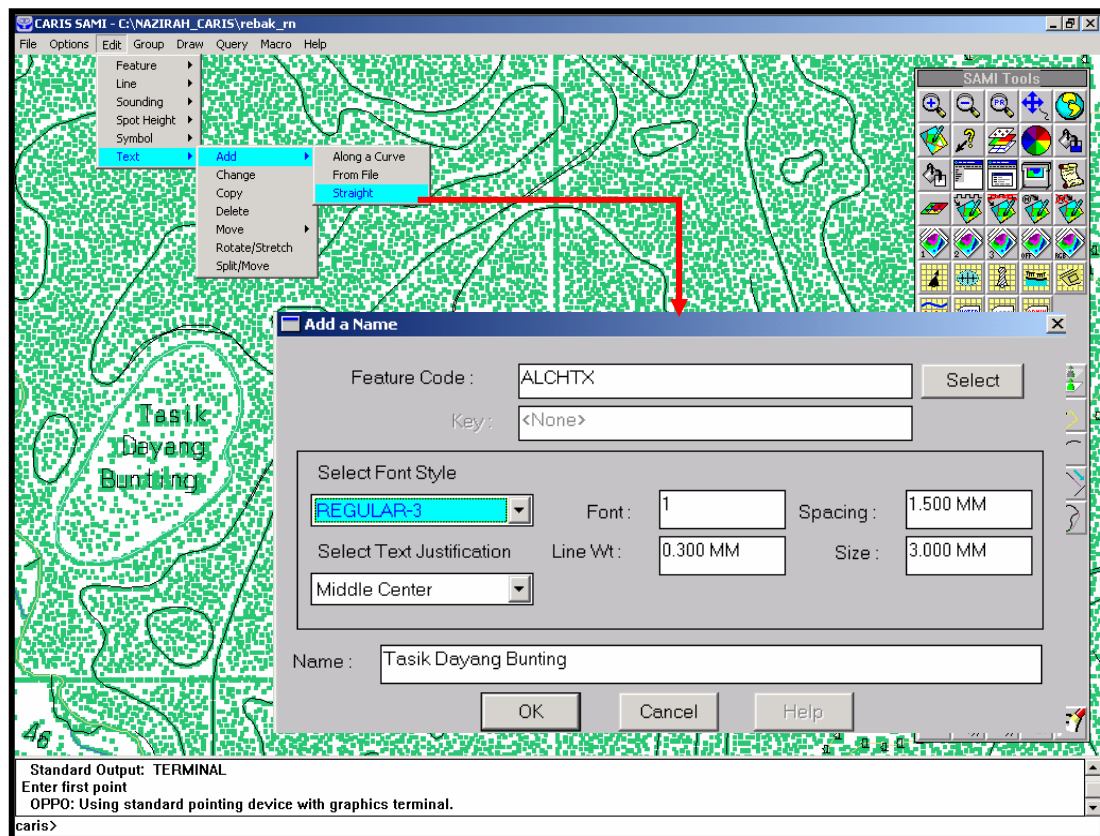


(a)



(b)

**Figure 4.10** Method of Inputting symbol (a) Using menu *Add a Symbol* for inputting building (b) Example of location for symbol building



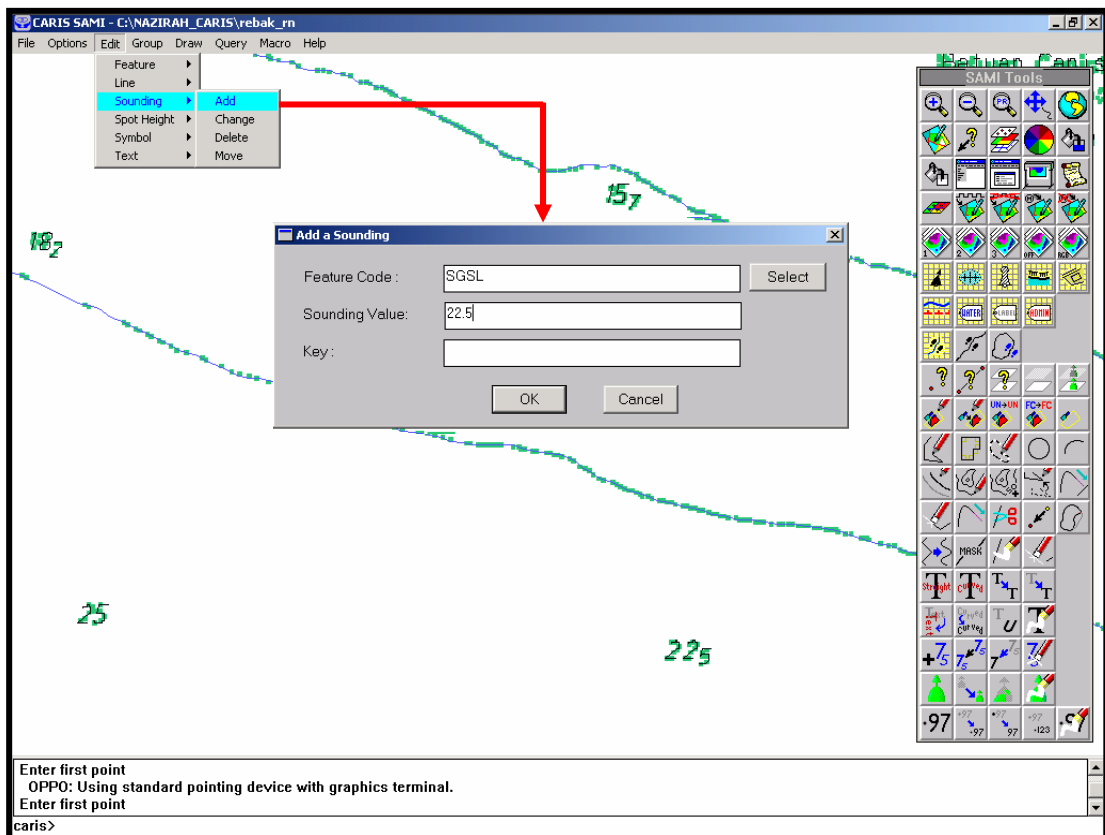
**Figure 4.11:** Inputting for Text

For the depth value, there are two ways can be done, which are semi-automatic or using *Add Sounding*. In this study, *Add sounding* is used because it is easier and able to provide an accurate depth value (Figure 4.12). For some specific depth, their characters as shown in Table 4.3 are used as feature code before inputting the depth value related and the result of the depth value for this study are shown in **Appendix E**.

**Table 4.3:** Specific Characters for feature code of depth value

| Feature Code Depth Value | Specific Characters | Description       |
|--------------------------|---------------------|-------------------|
| -SGSL                    | -                   | Dry Height        |
| SGSL                     | None                | Surveyed Depth    |
| KSGSL                    | K                   | Unknown Depth     |
| DLDSWSW                  | S                   | Swept Depth       |
| SGSLNB                   | N                   | Unexpected Seabed |

|        |     |                  |
|--------|-----|------------------|
| (SGSL) | ( ) | Depth in Bracket |
|--------|-----|------------------|



**Figure 4.12:** Inputting for Depth Value

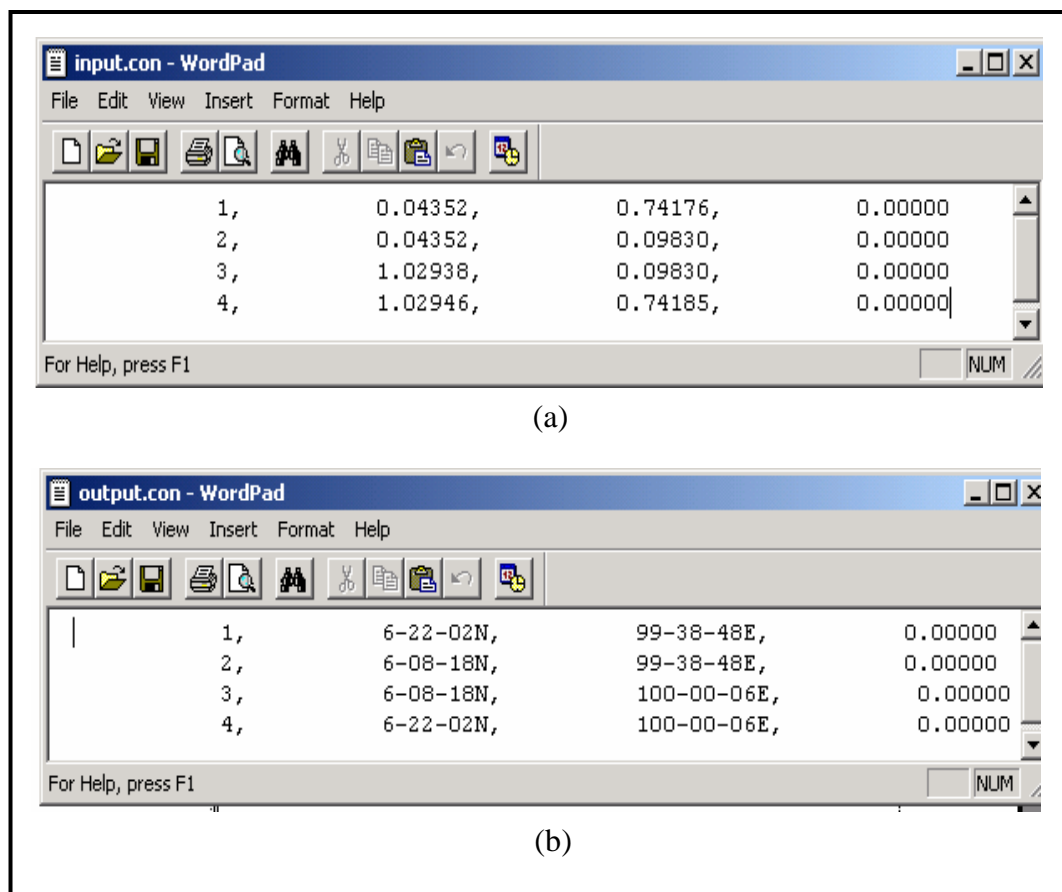
#### 4.4 Creation of Control File

The final process that needed to be done in CARIS SAMI is the creation of control file. It needs user to produce a control file to register the digitized image into a new map file. In this study, there are 2 types of control file, which are input file and output file. The positions of four control points are shown in Table 4.4.

**Table 4.4:** Position of Four Control Points

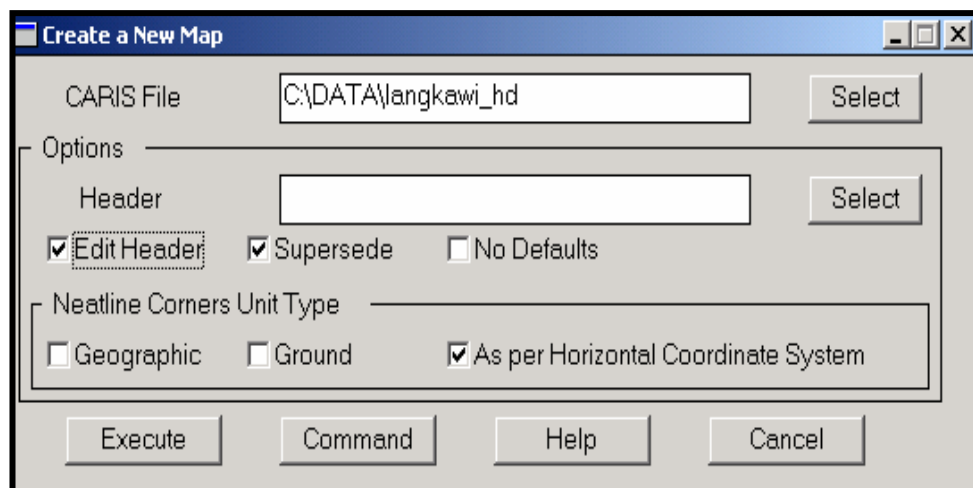
| No. Points | Position    | X, Y             |
|------------|-------------|------------------|
| 1          | Above left  | 0.04352, 0.74176 |
| 2          | Below left  | 0.04352, 0.09830 |
| 3          | Below right | 1.02938, 0.09830 |
| 4          | Above right | 1.02946, 0.74185 |

Next, File for Ground Control Point or GCP also has to be formed by copying the input.con file into a new file called output.con and replace the four initial control points into the ground coordinate that known. Example of control file for input and output data that formed are shown in Figure 4.13.

**Figure 4.13:** Control File (a) Input Data (b) Output Data

## 4.5 Map Registration

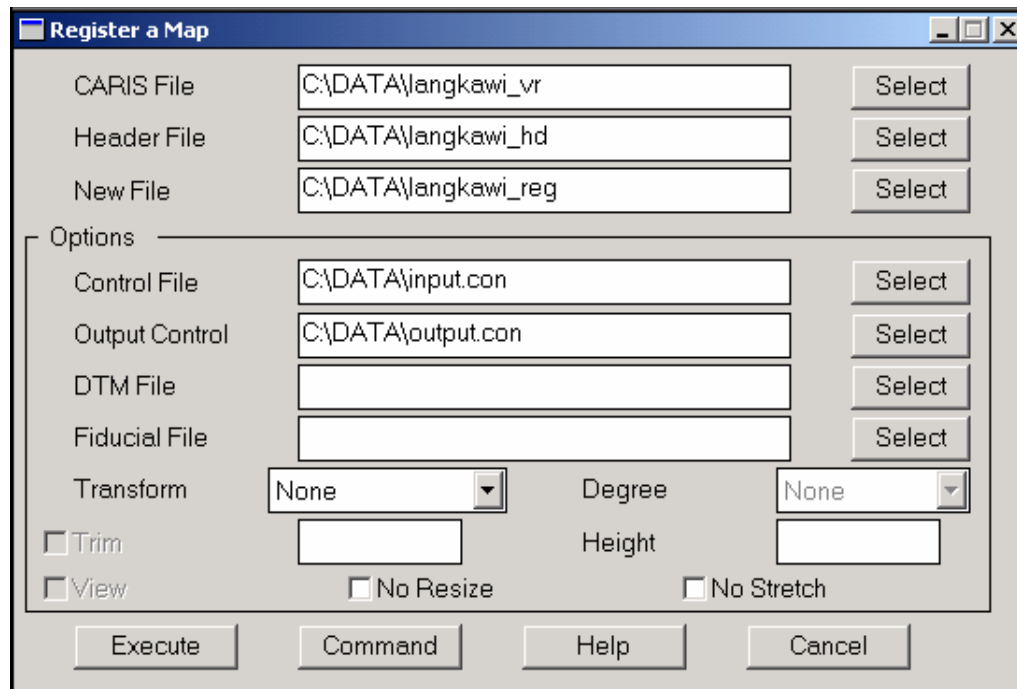
Map registration in this study is to link the nautical chart to the real coordinate so that it provides the real map orientation on ground. Therefore, next step selected the menu *Create A New Map* from Map Creation and Management Modular in CARIS Tools as shown in Figure 4.14. It will generate a header file that kept metadata of chart. Process of Create A New Map can be viewed in **Appendix F**.



**Figure 4.14:** Generating New CARIS File Using Menu *Create A New Map*

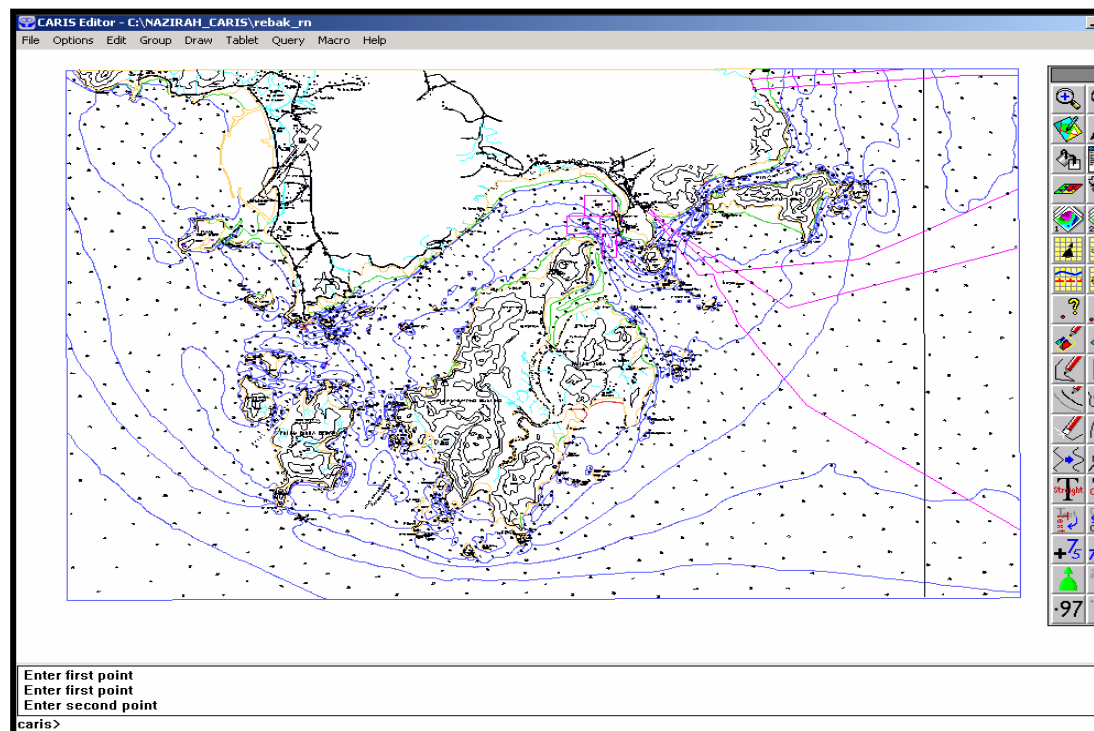
Then, registration map can be done using menu *Register a Map* in Map Creation and Management Modular (Figure 4.15). The process of registration can be viewed in **Appendix G**.





**Figure 4.15:** Register MAL5622 Using Menu *Register a Map*

The result of this process is shown in Figure 4.16. Since MAL 5622 has been registered, the next step will be generating topology for it.



**Figure 4.16:** Result of Chart after registration

## **4.6 Network Topology**

Network topology is needed to build before generating polygon topology. It can be divided to three steps, which are creation of thematic layers, creation of network topology file and process of producing network topology. The details of each step will be explained later.

### **4.6.1 Creation of Thematic Layers**

Thematic layers able to present the data layer in a chart. Thus, each data that inputted during digitisation has to define a reference number for each thematic layer. The reference number will exist directly when user number inputted in CARIS GIS 4.4a, each user number represent the same value with theme number.

In this study, there are 6 groups of theme number generated and their descriptions are shown in Table 4.5. Creation of this thematic layer is done with the reference of Specification Product ENC S-57 Edition 3.0.

Before the process of network topology started, there are three steps have to be implemented in creation of network topology file, which are:

- (i) Generating arc from lines.
- (ii) Locating intersection points.
- (iii) Trimming arc at intersection points.

**Table 4.5:** Description for Theme Number

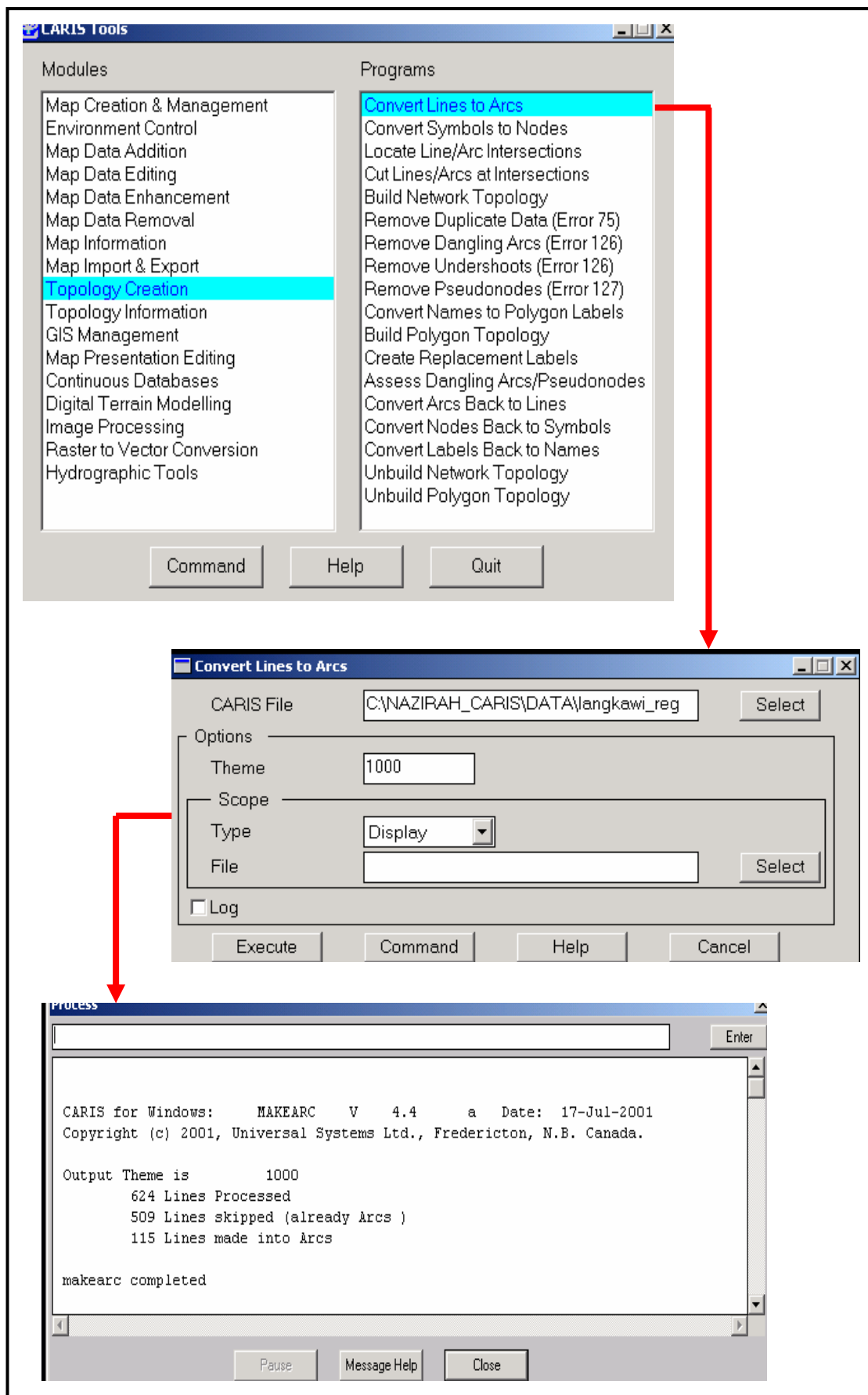
| <b>Theme Number</b> | <b>Description</b>                     |
|---------------------|--|
| 1000                | Object involved land surface           |
| 2100                | Sea area                               |
| 2300                | Direction tools                        |
| 2400                | Government management area             |
| 2500                | Depth                                  |
| 2600                | Contour of topography and road network |
| 2800                | Cable area                             |

#### 4.6.2 Creation of Network Topology File

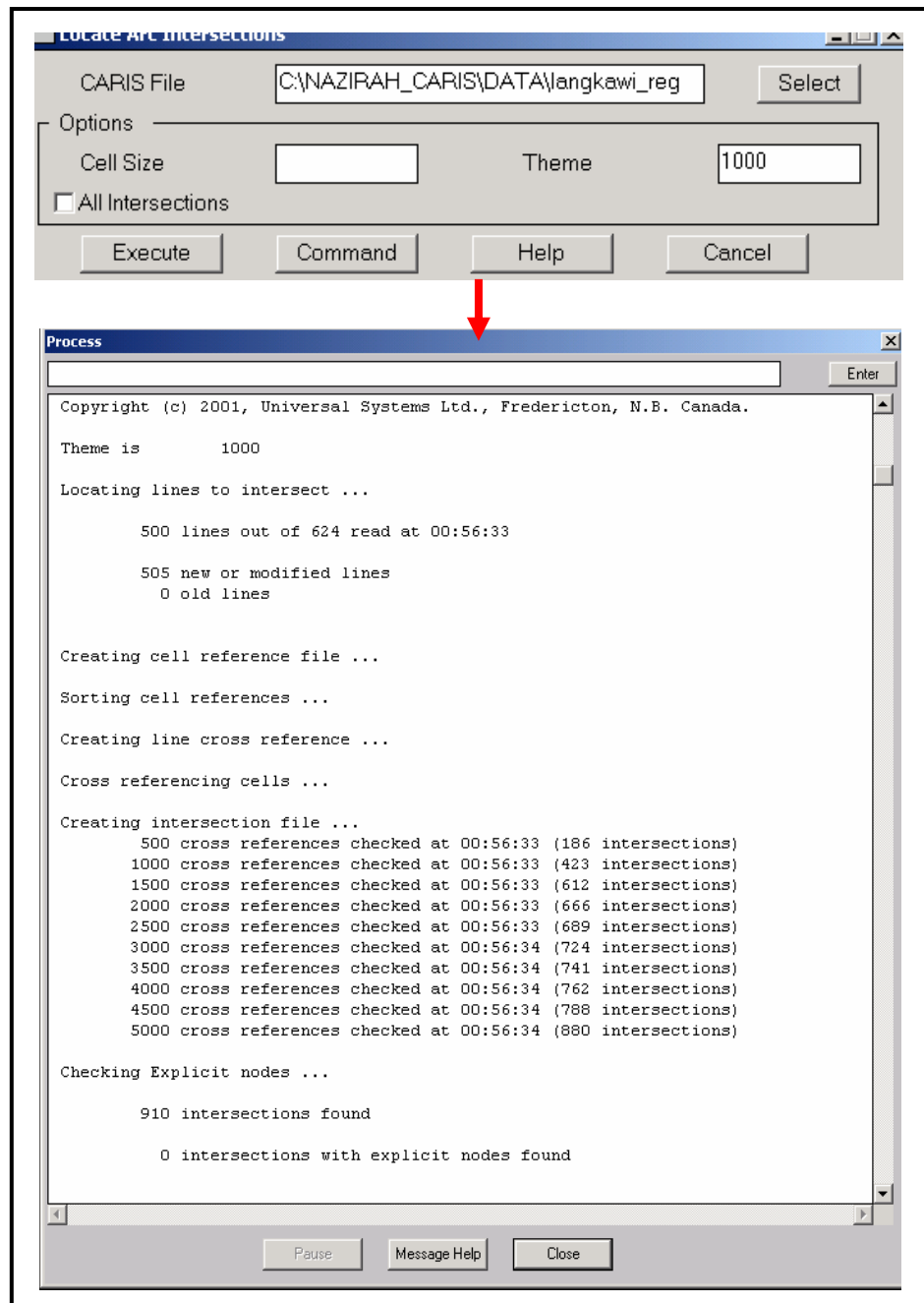
First, all of the lines in the file have to convert into arc with topology for some of the thematic layers that related. Figure 4.17 shows the procedures of conversion in theme number 1000 with the help of *CARIS Tools > Topology Creation Module > Convert Lines to Arc*.

Second, it is needed to locate the intersection points whereby some arcs will be intersected. The menu for this step is *CARIS Tools > Topology Creation > Locate Arc Intersection* (Figure 4.18)

In order to obtain the complete result as shown in Figure 4.17 and 4.18, each step has to be followed consequently. After this, network relationship has to be formed within these arcs.



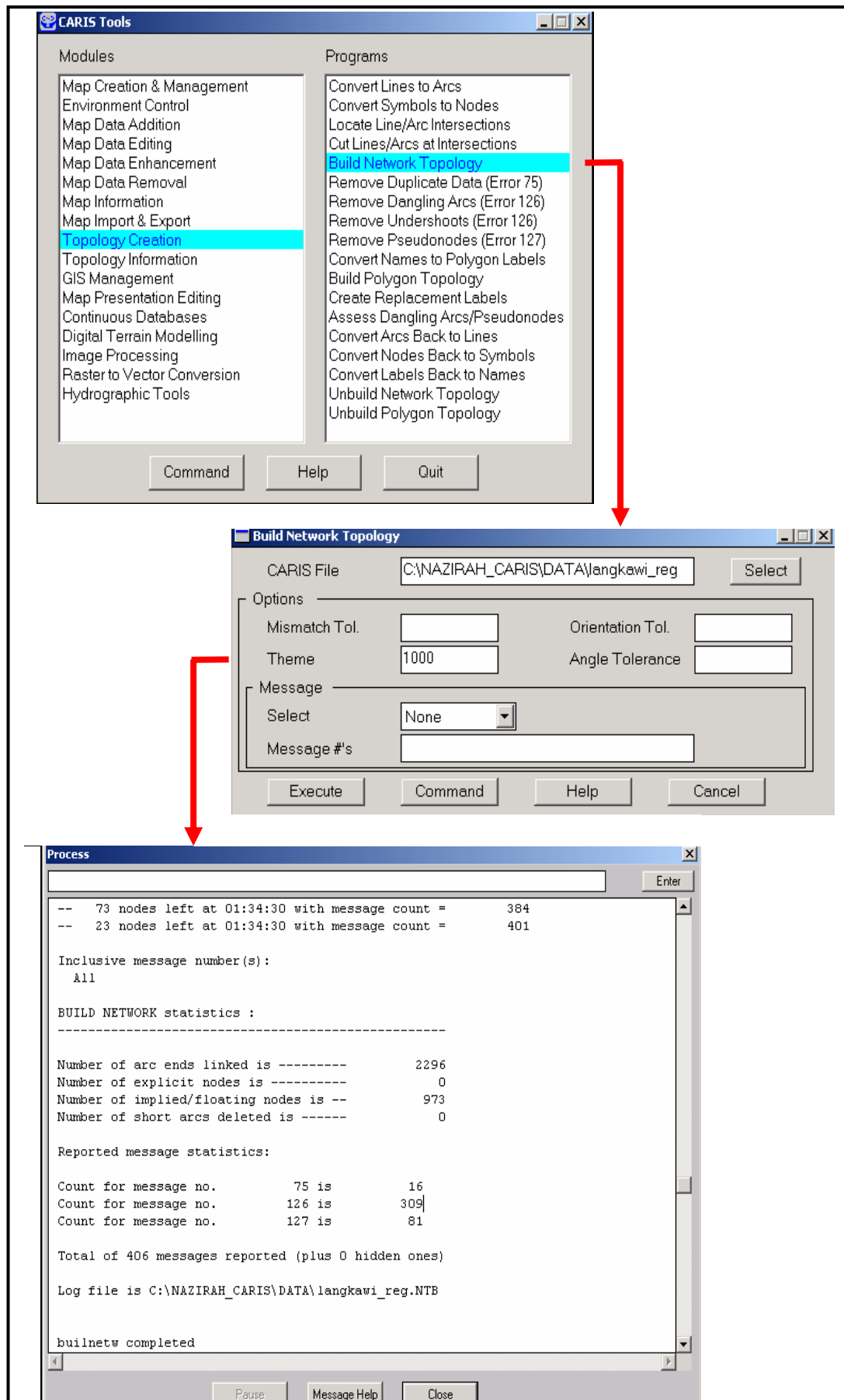
**Figure 4.17:** Converting Lines to Arcs



**Figure 4.18:** Locating Arc Intersection

### 4.6.3 Process of Producing Network Topology

For producing network topology, menu *Build Network Topology* is selected from Topology Creation modular. This process is shown in Figure 4.19.



**Figure 4.19:** Process of Producing Network Topology

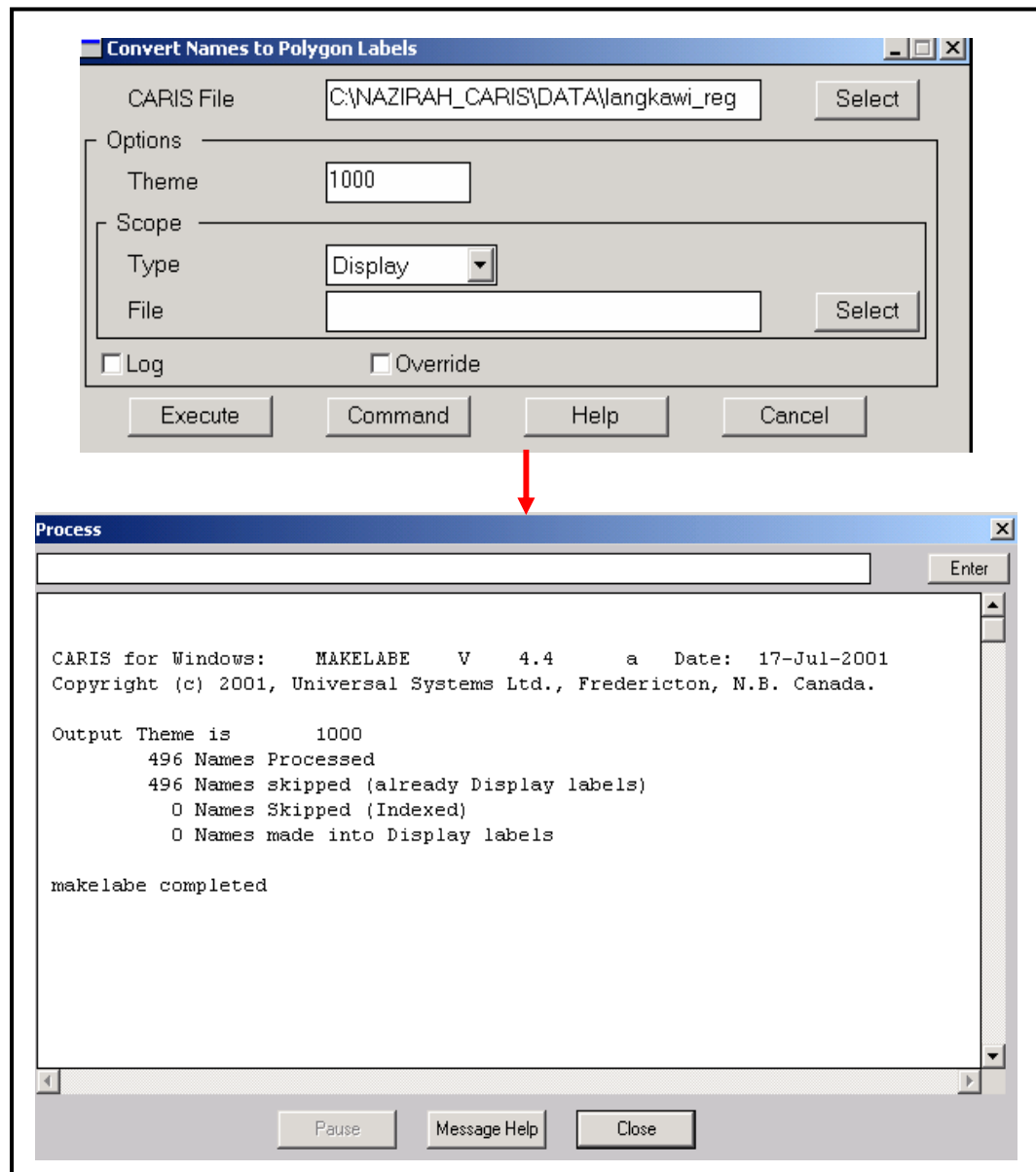
From the process of create network topology as shown in Figure 4.19, some useful information obtained. A statistic shows some processed data has occurred network topology error in reported message. The correction of network topology can be done through CARIS Editor with a log file produced (\*.ntb) to report the error condition.

## **4.7 Polygon Topology**

Process of polygon topology will enable the polylines and arcs to form into polygon with topology. But, this process can only be done after network topology completely formed.

### **4.7.1 Labelling Polygon Keys**

Before creating the polygon topology in Topology Creation modular, it is needed to label the keys for each polygon with the help of menu *Convert Names to Polygon Label* as shown in Figure 4.20.

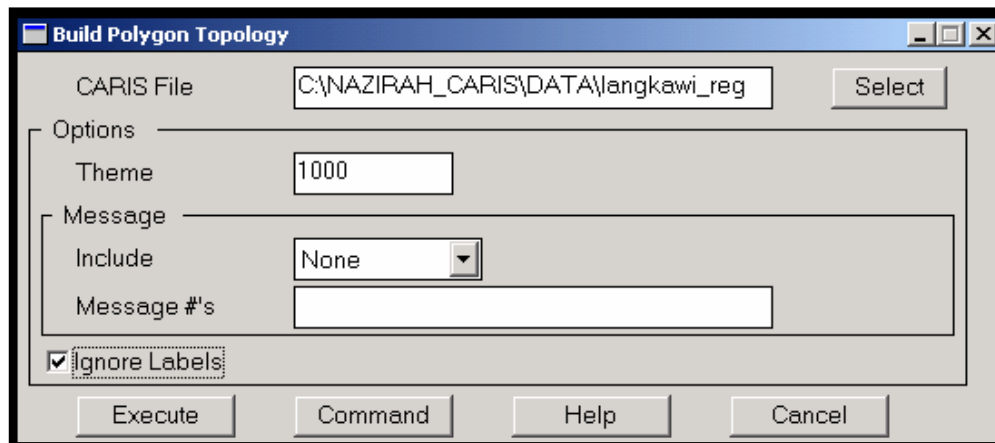


**Figure 4.20:** Convert Name to Polygon Label

#### 4.7.2 Building Polygon Topology

The polygon topology can be developed using the menu *Build Polygon Topology* from Topology Creation modular as shown in Figure 4.21.



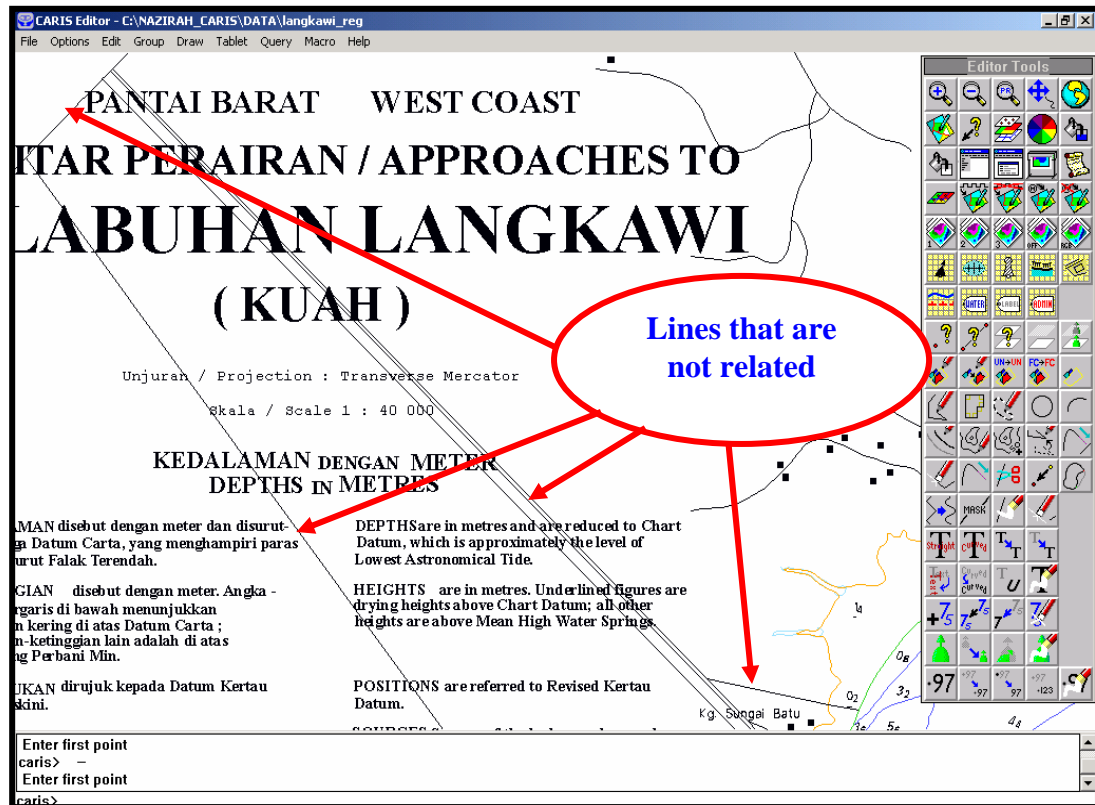


**Figure 4.21:** Method of Building Polygon Topology

However, the process of building polygon topology is advised to implement twice for:

- (i) Finding the topology error the related with networking.
- (ii) Finding the error related with polygon labelling.

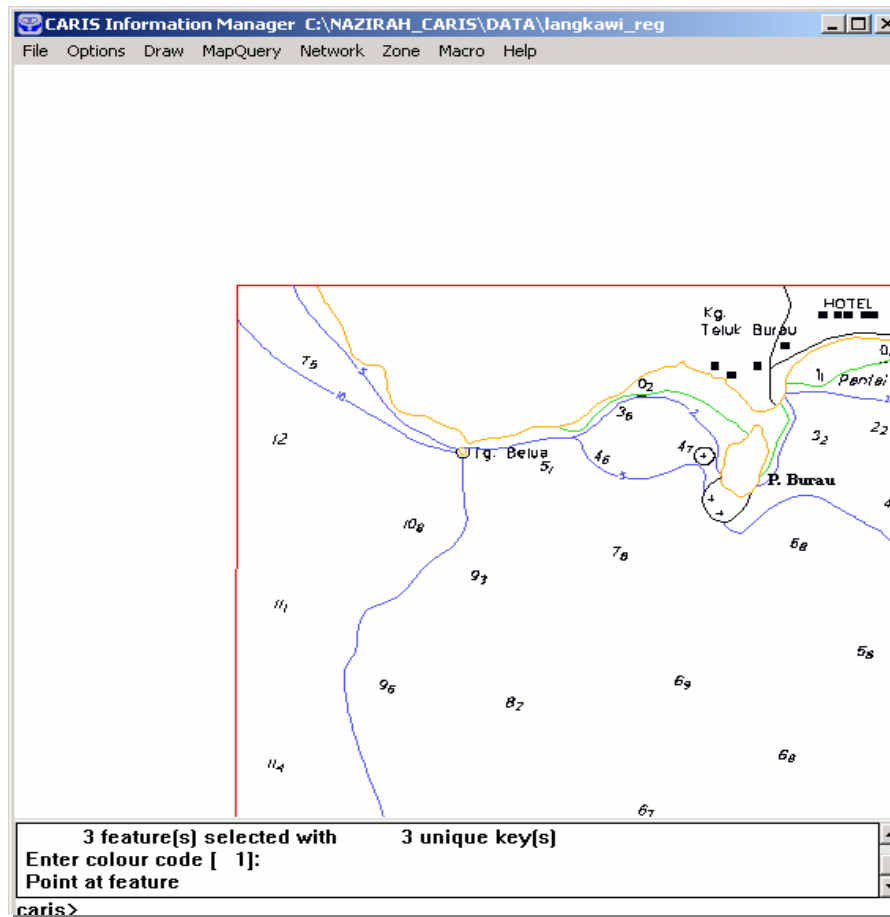
When the errors are found, it has to be corrected through CARIS Editor using menu *Edit > Topology > Highlight Error Markers*, the location of errors will be listed. The examples of listed error are shown in Figure 4.22. By using menu *Edit > Line > Delete > Whole Line*, user able to erase those lines that are not related but appeared after building polygon topology. Then, the process of building polygon topology repeated to restructure all the arcs that have changed.



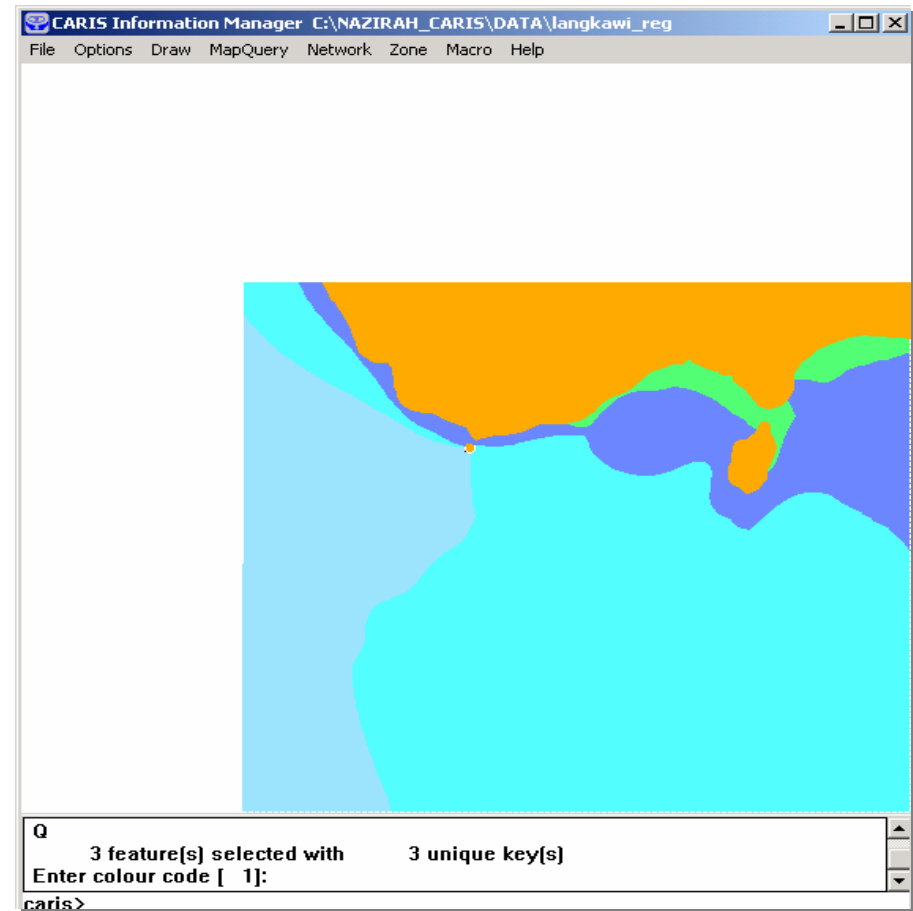
**Figure 4.22:** Example of lines that are not related

#### 4.8 Result of Digital Nautical Chart Using CARIS GIS 4.4a

A completed digital nautical chart can present all of the contents in paper charts into computer screen. Figure 4.23 (a) shows a small area from the digital chart in vector form without topology and Figure 4.23(b) shows the small area from the digital chart in vector form with network and polygon topology. The digital nautical chart produced by CARIS SAMI and CARIS Editor can be coloured after building network and polygon topology. A successful digital nautical chart for Langkawi Port is shown in **Appendix H**.



(a)



(b)

**Figure 4.23:** Small Area of Digital Nautical Chart that Digitised (a) Chart before process Building Topology (b) Chart after Process Building Topology

## **4.9 Conclusion**

From the result that shown in Figure 4.23, the digital chart in vector form has been produced successfully in this study although it is a time-consuming process. Data preparation using CARIS GIS 4.4a is a complicated process to be implemented especially during the initial stage if user lack of knowledge in scanning, digitise and topology.

Although the process to produce a vector chart using CARIS GIS 4.4a is very complicated, however it gives an experience and understanding toward conversion of raster data to vector data that widely being used. In short, CARIS GIS 4.4a can produce topological vector chart with completed hydrographic and cartographic information for Malaysian Charts.

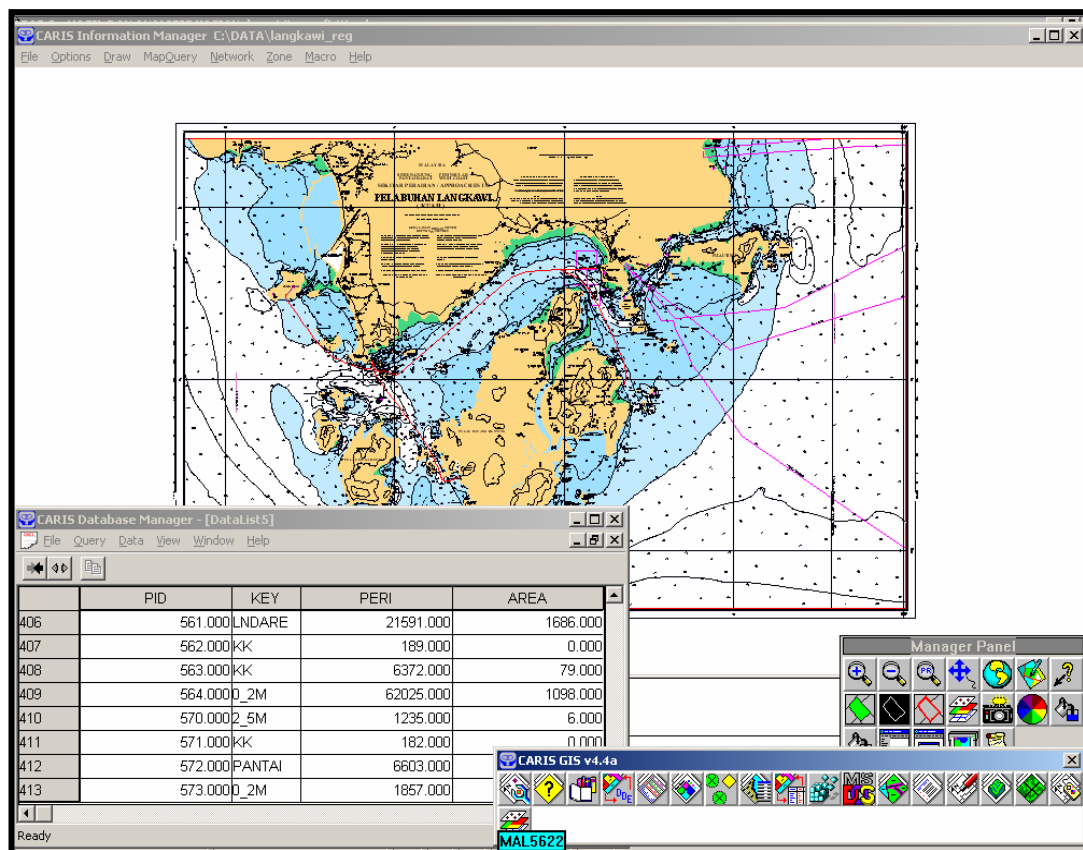
## CHAPTER 5

### PHASE I – RESULT AND ANALYSE

#### 5.1 Background

Spatial Data in this study is digital nautical chart that kept under the file name of *langkawi\_reg.des* whereby its attribute data kept in the form of *\*.dbf* tables that produced using Microsoft Excel. The result of this study enable users to access the digital nautical chart by clicking a new icon that set on CARIS panel icon as shown in Figure 5.1.

‘MAL’ is the short form of country that produces chart, which is Malaysia and 5622 is the chart reference number for a Langkawi in Malaysia. Thus, the icon name for the presentation of result is named in MAL 5622. If there will be different area charts developed in future, CARIS user able to add a new icon in CARIS icon panel according to their chart number. Through this way, user will definitely obtain the needed information in short time.



**Figure 5.1:** Example of Result Accessed through Icon MAL 5622

Using *CARIS Setup*, CARIS user could decide the type of data presentation for client. Basically, clients really need some information as listed below:

(i) CARIS Information Manager

Enable user to access the related digital nautical chart directly and execute spatial analyses using menus on that modular.

(ii) CARIS Database Manager

Enable user to access attribute data that related with the digital nautical chart.

(iii) CARIS Report

Enable user to view the accessed data in the form of report directly.

## **5.2 Analyses for Updating Data**

The development of electronic navigational chart normally need a mechanism for updating data in order to help user in adding data or deleting data from time to time. Nowadays, there are two kinds of method for updating data in electronic navigational chart application, which are:

- (i) Updating data by developer, and
- (ii) Updating data by users based on the information of Notice to Mariners.

For data that updated by user themselves, software developer will prepare a modular for user to edit data and the way of implementation might be different according to the software and system needs. CARIS GIS 4.4a enable user to edit and update particular data spatial through CARIS Editor or CARIS SAMI. The aspect of relevant data editing that been succeed in this study will be explained further later.

### **5.2.1 Adding Depth Information**

As we know, the depth value will always change from time to time due to the changes of tide. Therefore, related parties will execute digging task to remove sediments occasionally depends on the need of certain navigational path especially for those located nearby port or estuary.

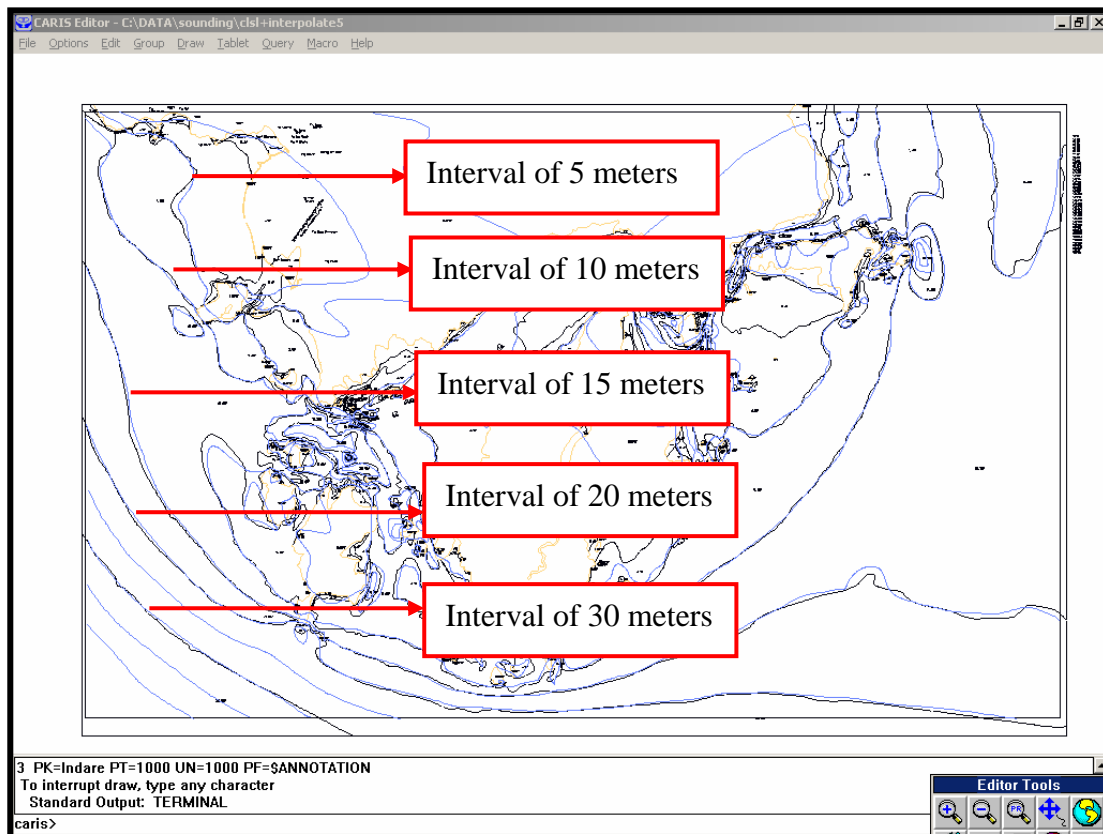
After the execution of digging task, hydrographic surveying will be implemented for that particular area to redefine the depth value. Those surveyed data (bathymetry data) will then be processed and plotted on the relevant nautical chart. In this study, bathymetry data could be edit and plotted on the relevant data layer using menu *Map Creation and Management > Merge Two Maps*. However, user needs to call out the new bathymetry data using menu *Hydrographic Tools > Import Sounding Data* which located in CARIS Tools menu for converting the original bathymetry data into CARIS file.

### **5.2.2 Interpolation of Contour Based on Latest Depth Value**

Interpolation of contour for surveyed depth value can be done using menu *Digital Terrain Modeling > Interpolate Contour* in CARIS Tools modular. In this study, there is no re-surveyed depth value, thus a test was run on the digitised depth value to generate new contour. The objective of this test is to compare the existing contour line on nautical chart with the generated contour line.

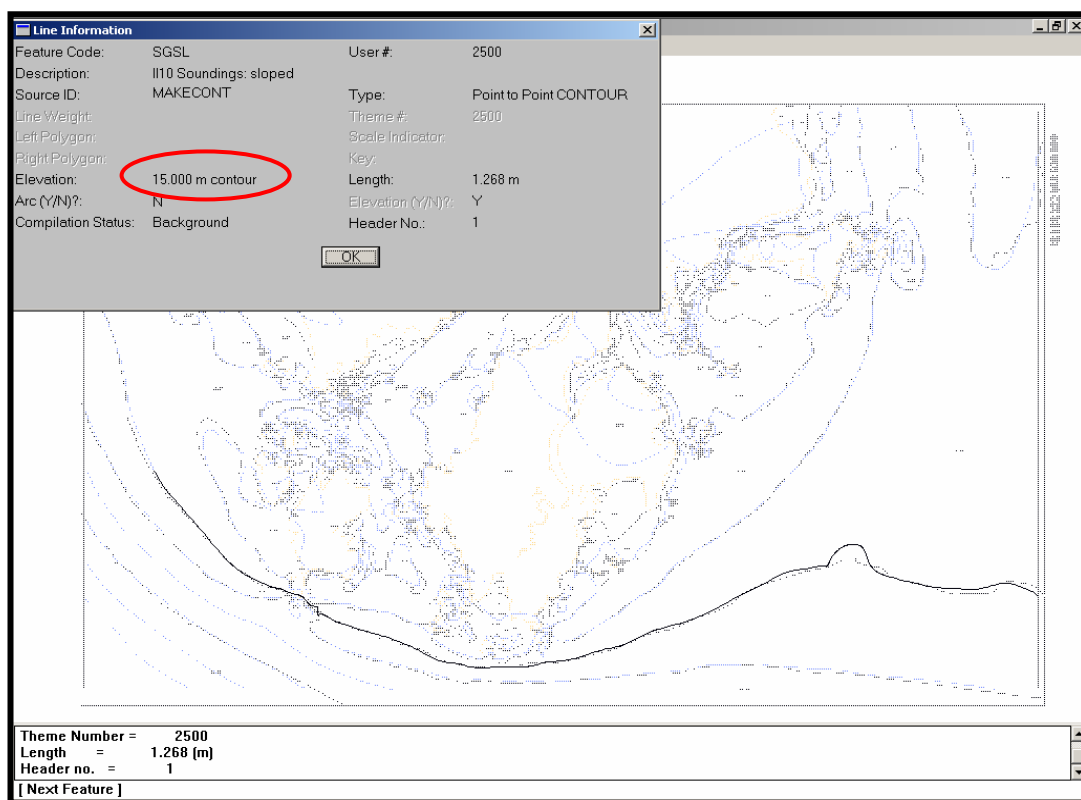
Using menu *Interpolate Contour* and the result is showed in Figure 5.2. From there, it is clear to see the generated contour lines are almost same with the existing contour line on nautical chart. The generated contour lines are in blue and the existing contour lines are in black. Interval for this contour interpolation is 5 meters.



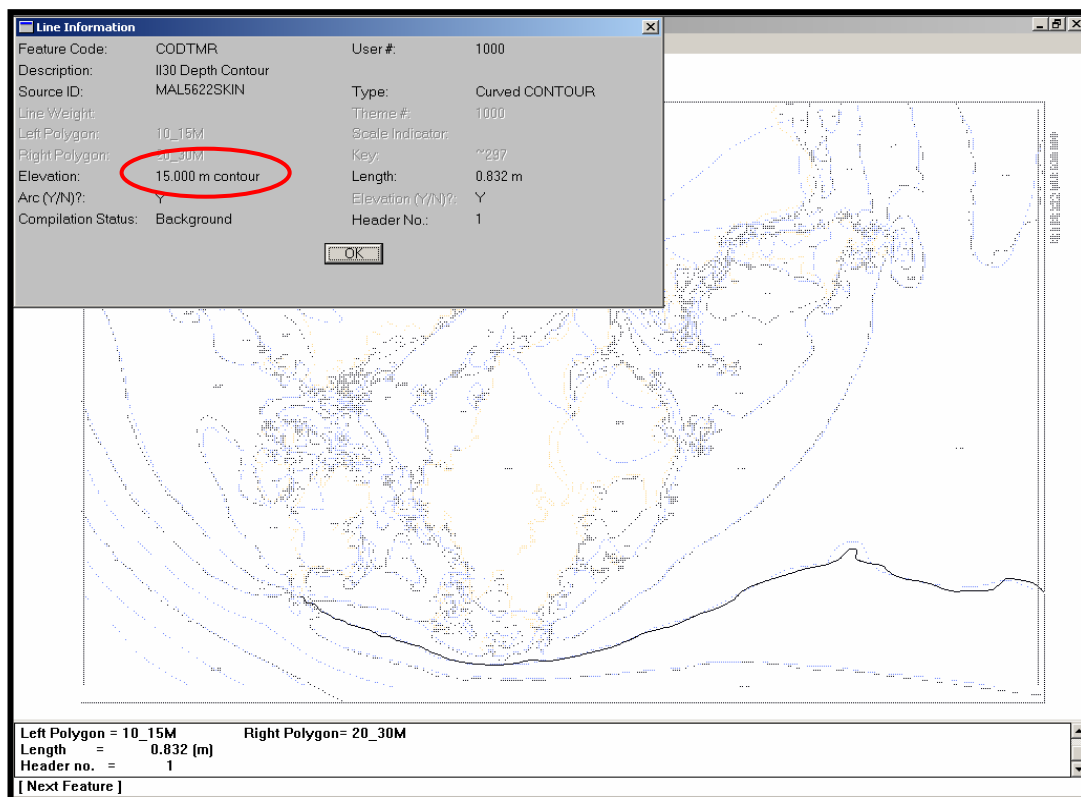


**Figure 5.2:** Comparison between Generated Contour Lines with Original Contour Lines on Nautical Chart.

Menu *Query > Information about Features* in CARIS Editor modular enable user to view the information of both original and generated contour lines. Figure 5.3(a) and (b) shows the value of 15 meters for both types of contour lines. Result of the generated contour with an interval of 5 meters shows only slightly different with the original contour. Another result of comparison test for generated depth contour lines with an interval of 2 meters shown in **Appendix I**.



(a)



(b)

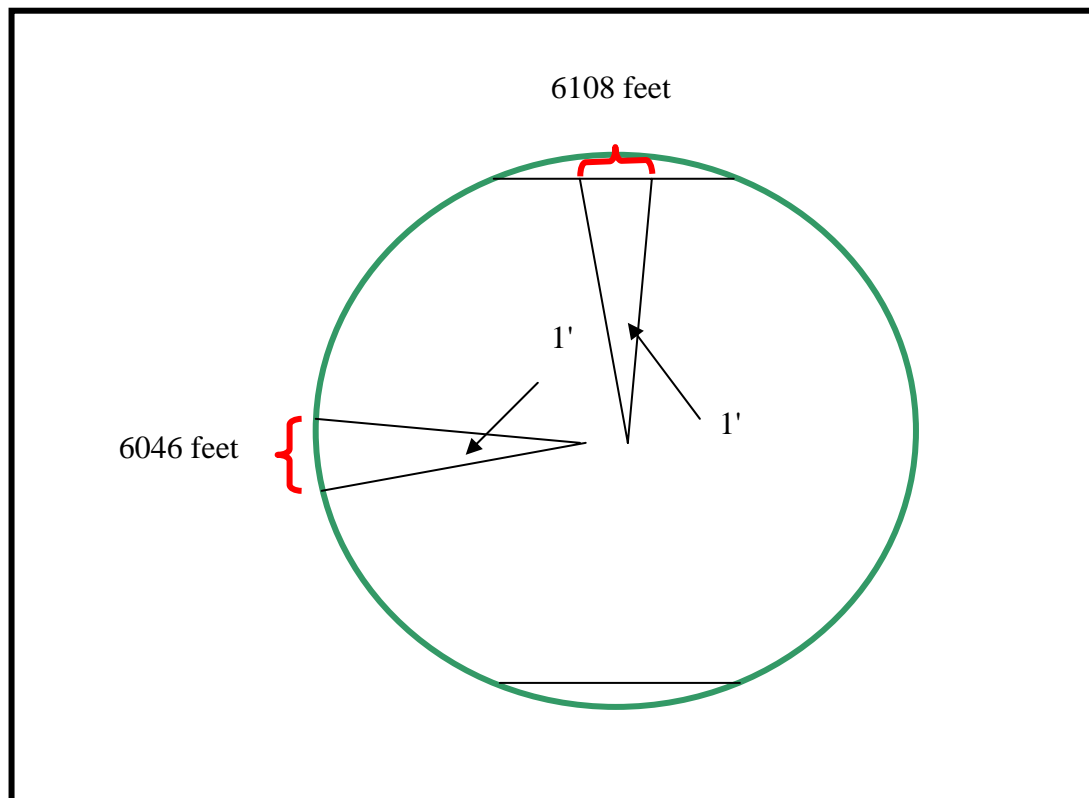
**Figure 5.3:** Interpolation of Contour Lines for depth (a) Generated Contour Lines  
(b) Original Contour Lines

### 5.3 Analyses For Vessel Navigation Information

Information of vessel navigation is a critical element for navigators in defining the navigational direction. Therefore, navigators really need latest data source in planning a safe navigation whether in the form of conversional or digital.

#### 5.3.1 Calculate Distance between Two Points

Nautical mile (nm) is the unit for calculating distance at sea. As we know, the shape of globe is wider at both poles, the curve distance on poles are more than khatulistiwa (Figure 5.4). It causes the distance by one minute on centre curve became 6,108 feet at poles and 6,046 feet at khatulistiwa (Motte *and* Stout, 1990).



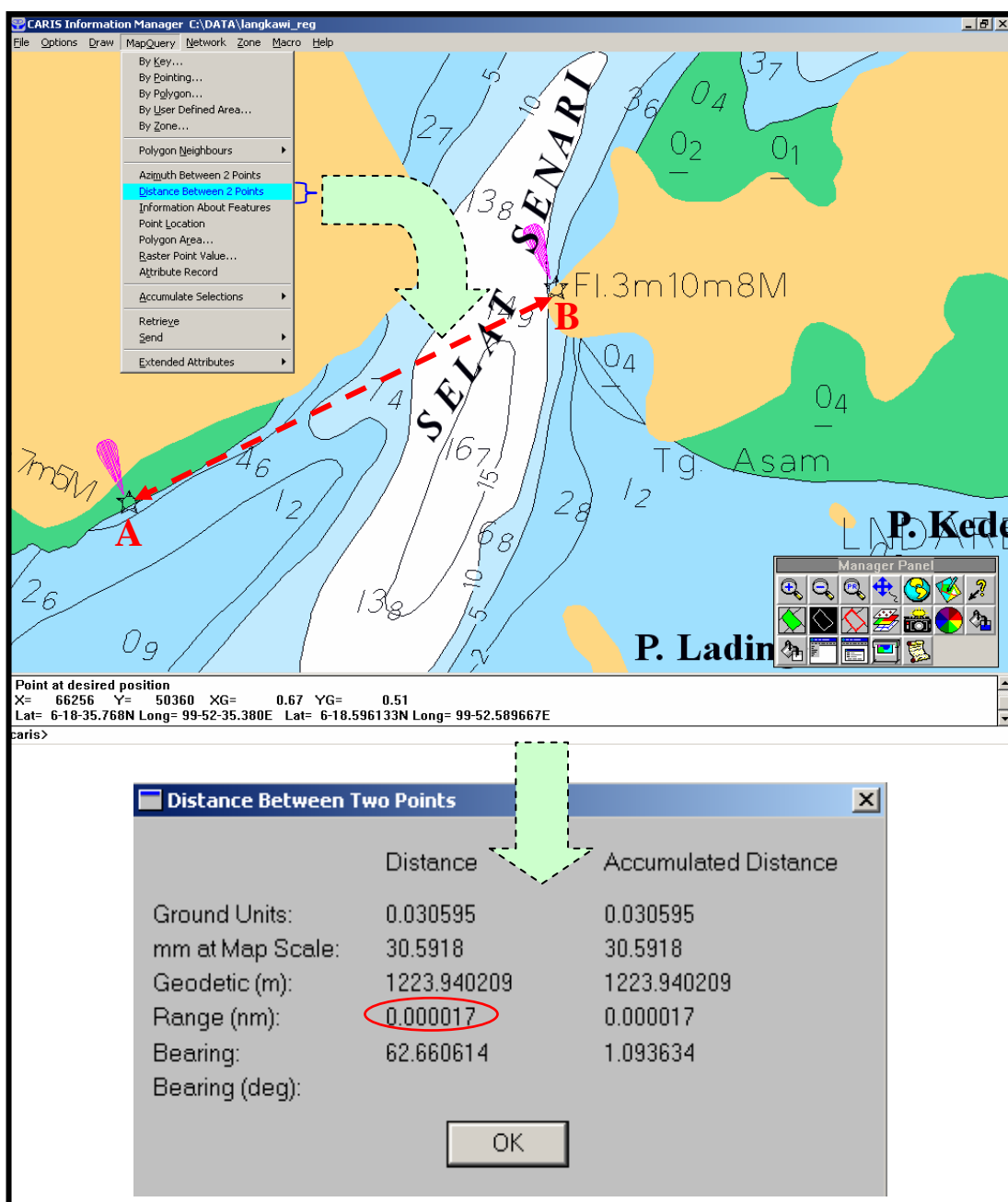
**Figure 5.4:** Distance at Poles and Khatulistiwa that Calculated in One Minute (1')

According to Table 5.1, it shows the difference between poles and khatulistiwa in one-minute records value is about 18.8976 meters or 0.010203888 nm. Despite that, the normal value used for nautical miles applications is 1,852 meters for 1 nm.

**Table 5.1** Comparison of Distance for a nautical mile at Poles with Khatulistiwa.

| <b>Distance</b>    | <b>Records in foot<br/>(')</b> | <b>Records in<br/>meter (m)</b> | <b>Records in nautical<br/>mile (nm)</b> |
|--------------------|--------------------------------|---------------------------------|--|
| 1' at Poles        | 6,108                          | 1,861.7184                      | 1.005247516                              |
| 1' at Khatulistiwa | 6,046                          | 1,842.8208                      | 0.995043628                              |
| <b>Difference</b>  | 62                             | 18.8976                         | 0.010203888                              |

Referring to Figure 5.5, distance between two points can be obtained directly through menu *Map Query* in CARIS Information Manager. Using that menu, user will receive information such as Ground units, mm at map scales, geodetic distance, range distance and bearing. Based on Figure 5.5, it shows the given distance in nautical mile is not fully accurate.



**Figure 5.5:** Distance from A to B Obtained through Map Query Using CARIS Information Manager Modular

Distance for a nautical mile should be same with 1,852 meters. Thus, the actual distance in nautical mile between two points should be calculated in this method:

$$\text{We know that, } 1 \text{ nm} = 1852 \text{ m}$$

$$\begin{aligned}
\text{Thus, Distance (nm)} &= \frac{\text{Geodetic Distance (m)}}{1852 \text{ m}} \\
&= \frac{1223.940209 \text{ m}}{1852 \text{ m}} \\
&= 0.660874842 \text{ nm}
\end{aligned}$$

However, range distance given by CARIS in nautical mile is 0.000017 was calculated in this method:

$$\begin{aligned}
\text{Distance (nm)} &= \frac{\text{Map Scale Distance (mm)}/1000}{1852 \text{ m}} \\
\text{Thus,} &= \frac{30.5918/1000}{1852 \text{ m}} \\
&= 0.000016518 \text{ nm} \\
\text{Round off to 6 digits} &= 0.000017 \text{ nm}
\end{aligned}$$

As a conclusion, if user needs an application without involving navigational activities, the given geodetic distance value can be accepted. In contrast, if user needs the actual value in nautical mile then correction must be calculated as showed above based on the geodetic distance. Through this way, user will definitely obtain a suitable reading value.

### 5.3.2 Result of Network Analyses

Menu CARIS Network Analysis in CARIS Information Manager helps user to solve the network problems accurately. Example of Network Analyses included relational analyses and dispatching need graphic presentation for showing a complicated network. In this study, a suitable network analyses to be implemented is to determine the shortest path between two harbours or ports. Due to the safety vessel navigation is a critical issue, generating zone also needs to be done for surrounding

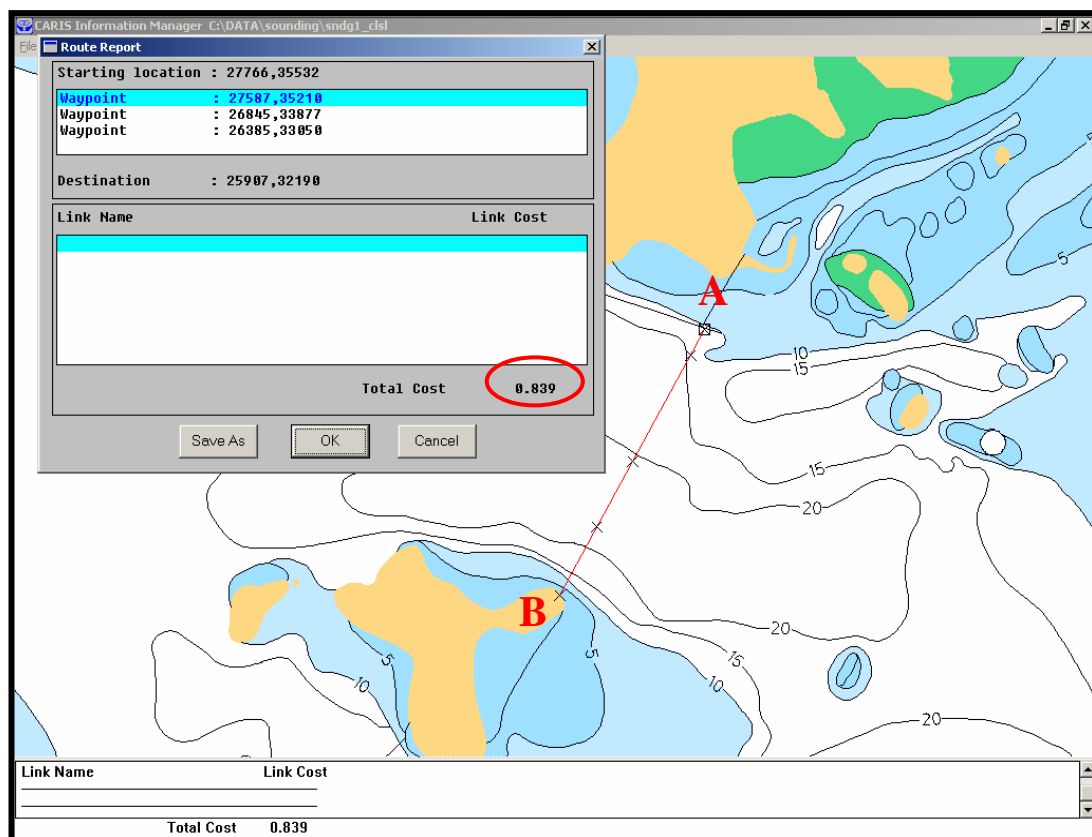
dangerous objects. Then, user could define a minimum distance to keep away from it.

### 5.3.2.1 Calculating Shortest Path

The main purpose for this analysis is to calculate the shortest path with minimum cost between two points in a network. Thus, some points are chosen to form a waypoint. Since MAL 5622 has no recommended track, as a test, a passage planning existed.

In this study, there are two essential elements to be searched, which are distance in nautical mile and vessel speed in knot (nautical mile in an hour). Menu distance between two points prepared in CARIS only given distance value for linear lines. Anywhere, calculation of curve distance (for geodetic distance) to obtain the actual value still can be done through network analyses.

Using menu *calculate shortest*, user will be requested to make waypoint along the planning path, example for destination A to B as shown in Figure 5.6. At the end point of path, user need to click on button 'G' to execute the automatic calculation program. It will start calculating the cost distance from first point to the ending point whereby distance A to B is 0.839 nautical miles.



**Figure 5.6:** Solution Cost for Distance A to B in Nautical Mile

### 5.3.2.2 Calculate Speed in Knot

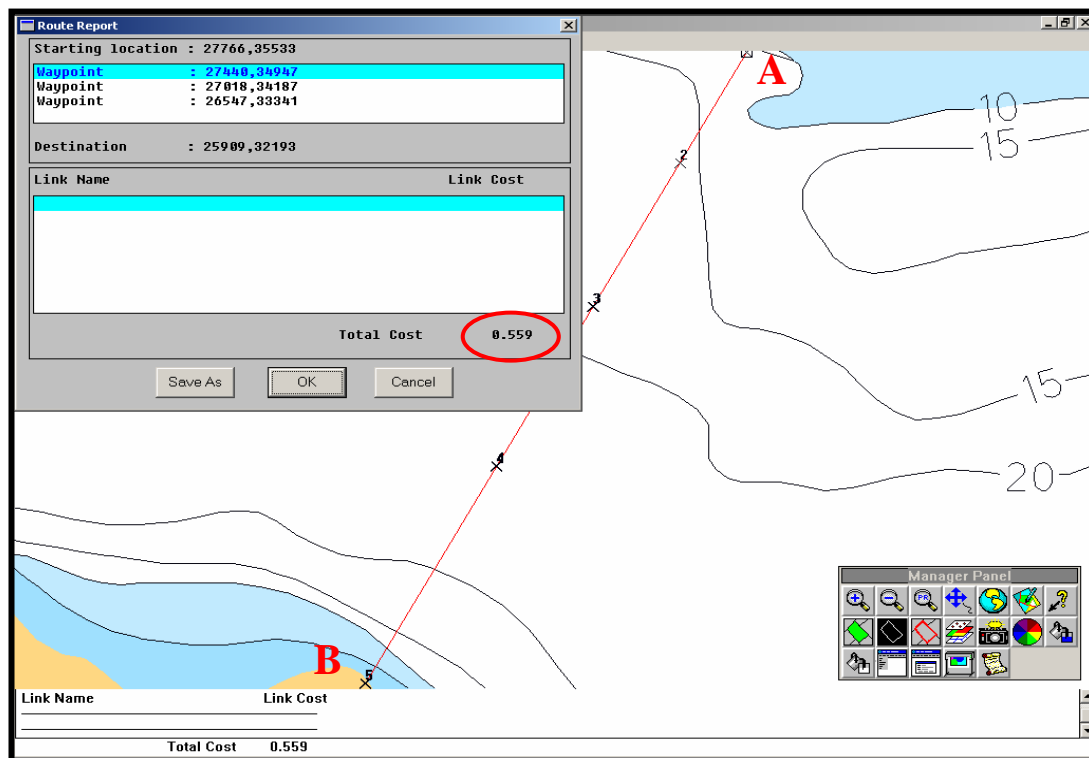
When user wants to obtain the cost model for speed in knot, a formula has to be formed. Speed (knot) is equal to total distance (nautical mile) in an hour, so the formula is as below:

$$\text{Speed (knot)} = \frac{\text{Distance (m)}/1852}{\text{Time (hour)}}$$

$$\text{Thus, formula for cost model} = (\text{Distance}/1852)/1.5$$



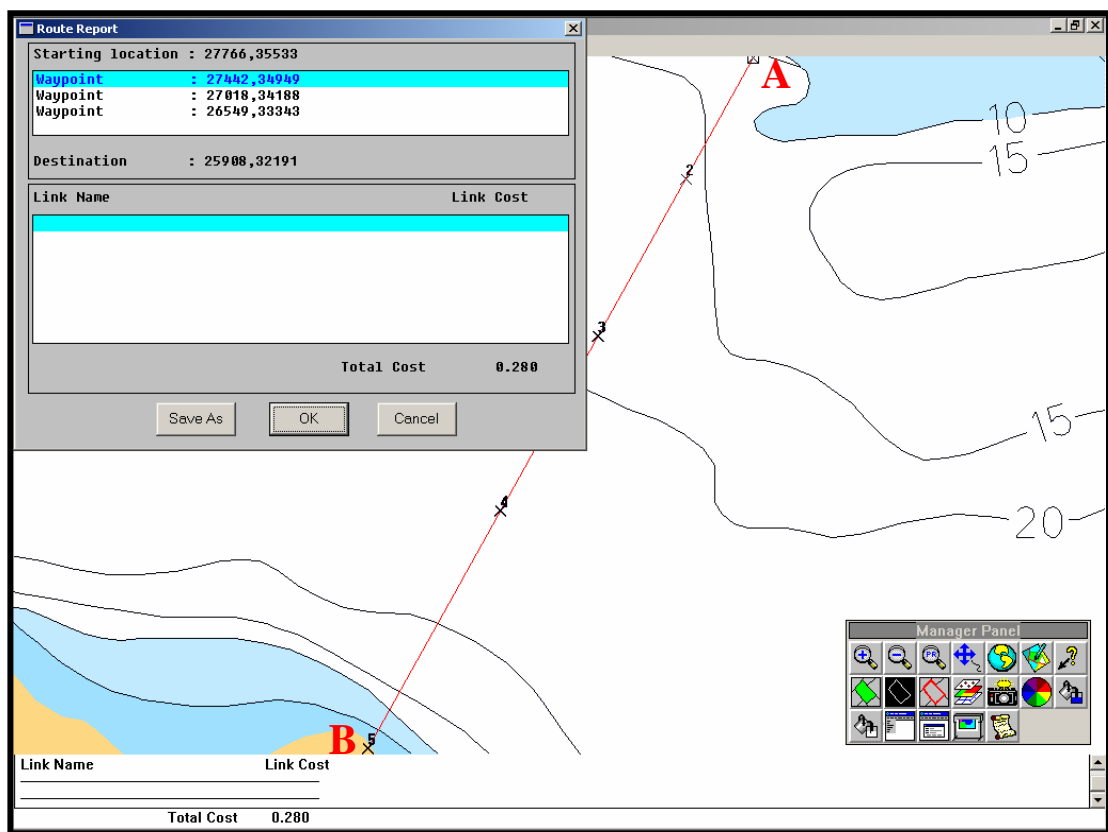
After inputting formula, user could execute menu *Network > Route > Calculate Shortest* to obtain the speed value from destination A to B in this case. 0.559 knots is the give speed when the time period defined as 1.5 hours (Figure 5.7).



**Figure 5.7:** Solution Cost for Speed Value from A to B

### 5.3.2.3 Calculate Period of Navigation

After determining the speed value, it is turn to calculate period of navigation from one destination to another. Using the same method to obtain distance and speed as mentioned above, user also could obtain the navigational period depending to the waypoint along passage planning from A to B (as shown in Figure 5.8) if the speed are in 3 knots.



**Figure 5.8:** Solution Cost for Navigational Period from A to B with Speed in 3 knots.

Program will calculate the total time taken along the navigational route whereby the period of navigation for 0.28 hours is equal to 16 minutes and 48 seconds in this study.

#### 5.3.2.4 Comparison between Obtained Distance and Speed with Calculated Distance and Speed

Result of solution cost for distance between destinations A to B given by CARIS is 0.839 nautical miles (Figure 5.6). Above distance value can be proved through below calculation:

(i) Determining parameter to form formula

NM = Distance in nautical mile (nm)

M = Distance in meter (m)

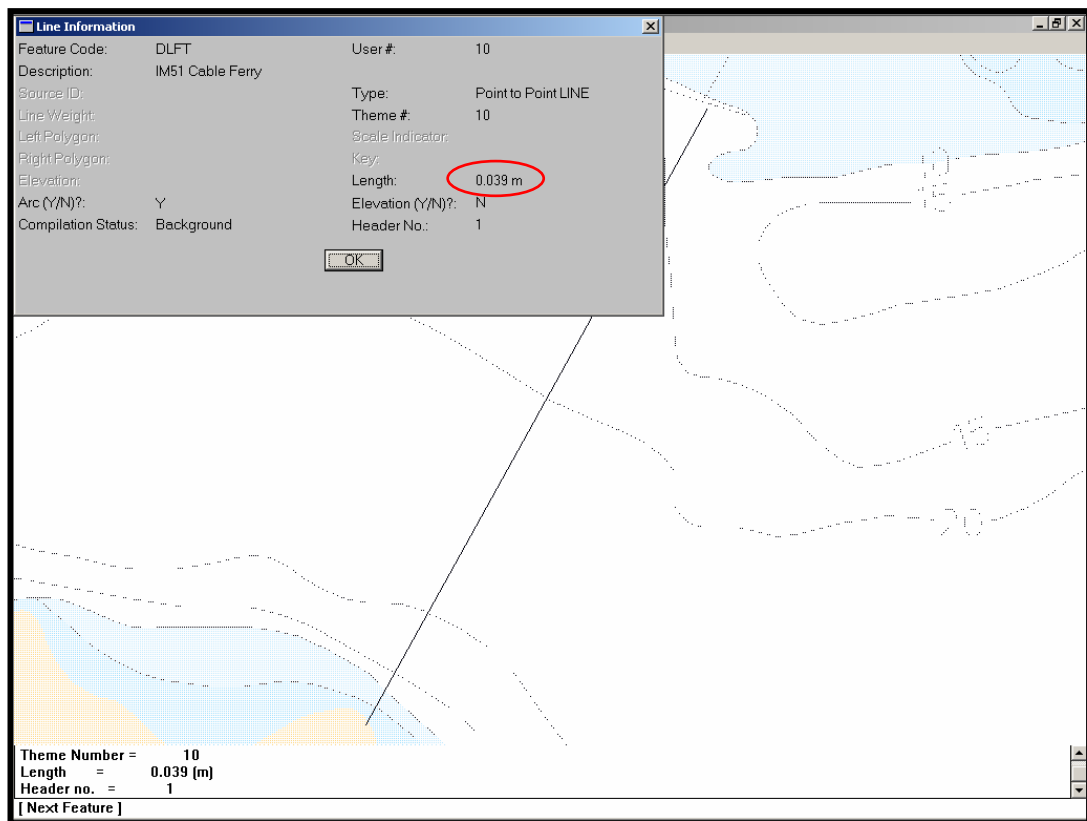
(ii) Forming formula

NM (nm) = M (m) / 1852 meter

Based on Figure 5.9, we knew that 0.039meters are the distance between destinations A to B depending to map scales (1:40000). Thus, distance in nautical mile should be calculated as below:

$$\begin{aligned} \text{NM (nm)} &= ((39 \text{ mm} \times 40000 \text{ mm}) / 1000000) / 1.852 \text{ meters} \\ &= 0.842333 \text{ nm} \end{aligned}$$

From the result of calculation, it is clear that calculated distance are same with the distance value give by CARIS, which is 0.84 nautical miles (round off to 2 decimal places).



**Figure 5.9:** Checking Distance from Destinations A to B using query line information

Next, comparison towards solution cost for speed between destinations A to B has to be done. As we know that speed given by CARIS is 0.559 knots. The above distance value can be proved through calculation

- (i) Determining parameter to form formula

Distance = nautical mile (nm)

Speed = knot

- (ii) Forming formula

Speed (knot) = Distance (nm)/ Time (hour)

Based on the period of navigation from destinations A to B is defined as 1.5 hours, speed should be calculated in this way:

$$\begin{aligned}\text{Speed (knot)} &= 0.842333 \text{ nm} / 1.5 \text{ hours} \\ &= 0.561555 \text{ knots}\end{aligned}$$

The calculated speed obtained from the above formula is 0.56 knots (round off to 2 decimal places). It shows that the value is same with the value given by CARIS if round off to 2 decimals place.

#### **5.4 Analyse Result of Zone for Vessel Navigation Path**

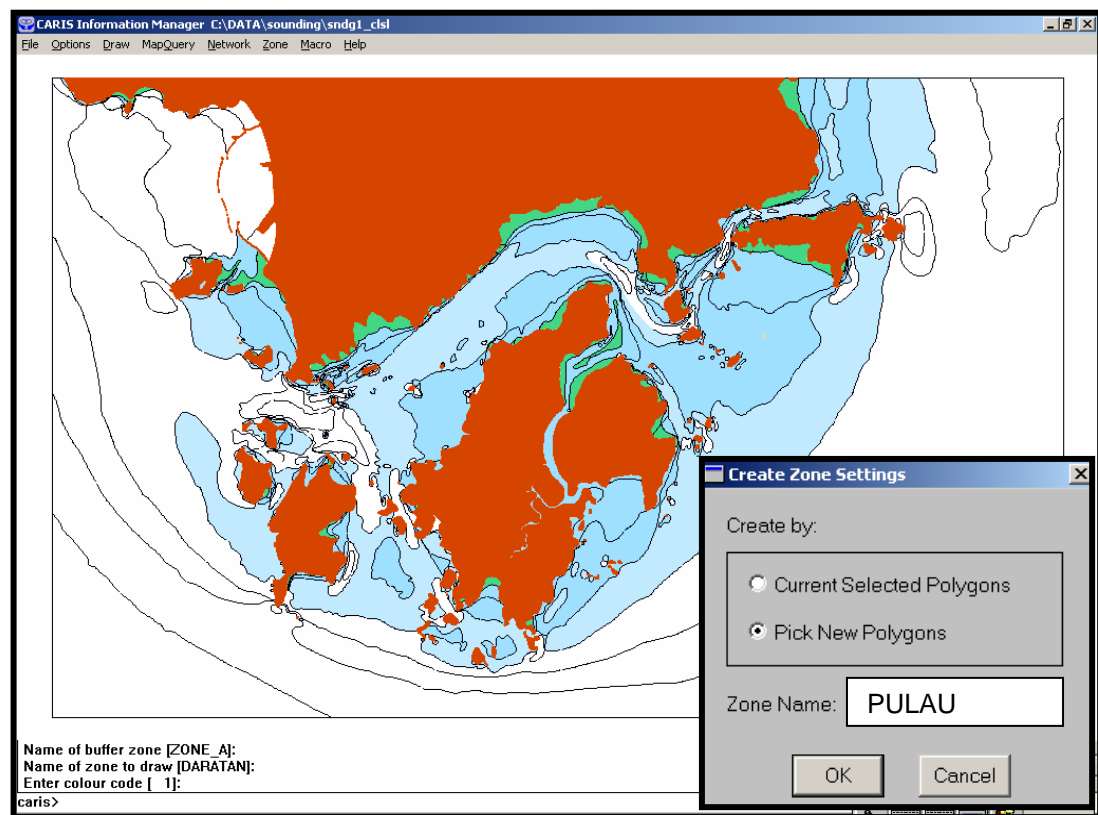
The main purpose for this analyses is to find safety navigational route for small boats and leisure crafts when they entering area of Langkawi Port. Determination of zone is based on the polygons of both land area theme and water area theme below 1000.

Some of the criteria related with small boats and leisure crafts are wide and length of boat, under keel clearance and others. Normally, the wide of boat can be divided to some categories, such as monohulls, catamarans and trimarans. Underneath each boat, there is keel to control the position so that it won't be unbalanced to right or left side due to the wind or tide. At the stern of boat, there is a tool called rudder to control its rotating direction whether to right or left side.

Therefore, there is no specialized or accurate method to present the actual calculation for small boats and leisure crafts that fulfil its criteria. However, the analyses zone helps user to suit small boat's criteria with the completed result analyses.

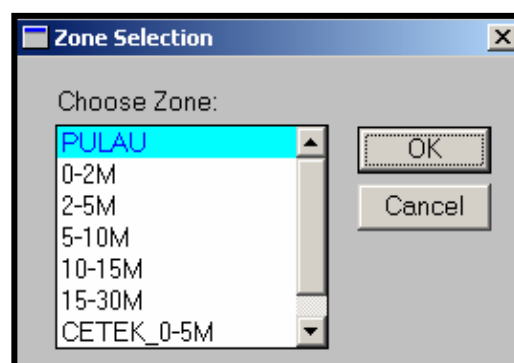
Other than that, user able to produce an analysis related with safety navigational route based on suitable depth contour for their boat draft. As an

example, user needs to create zone for land area (Figure 5.10). Therefore, menu *Zone > Create > By Polygon* is used. For each new zone, new name is given.

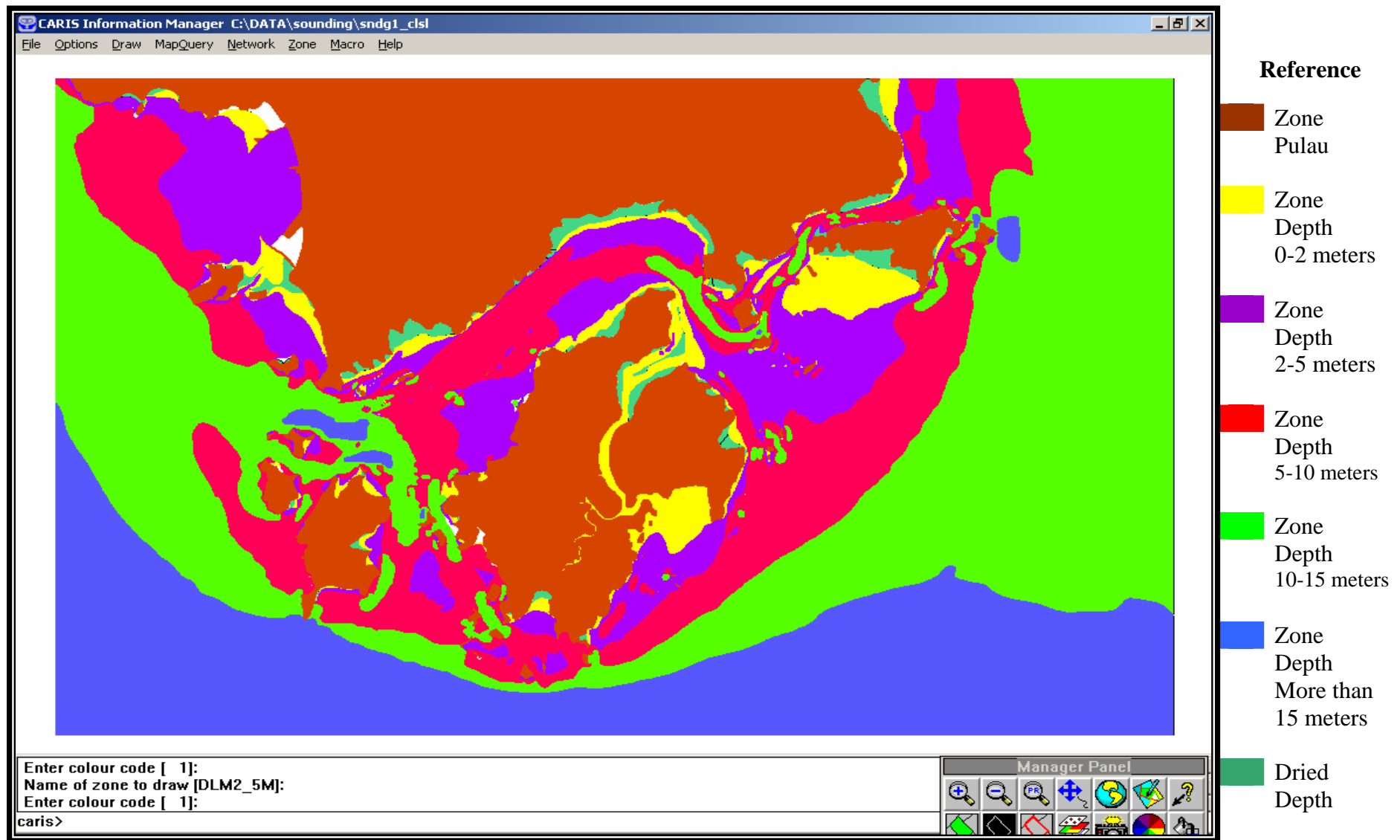


**Figure 5.10:** Created Zone for Land Area

Initially, there are 6 zones created in this study, which are PULAU, 0-2M, 2-5M, 5-10M, 10-15M and 15-30M (Figure 5.11) whereby the result of above zone are shown in Figure 5.12. Next steps are to operating these zones using menu *Zone Operation* that involved Intersection, Union, Subtract and Exclusive OR.

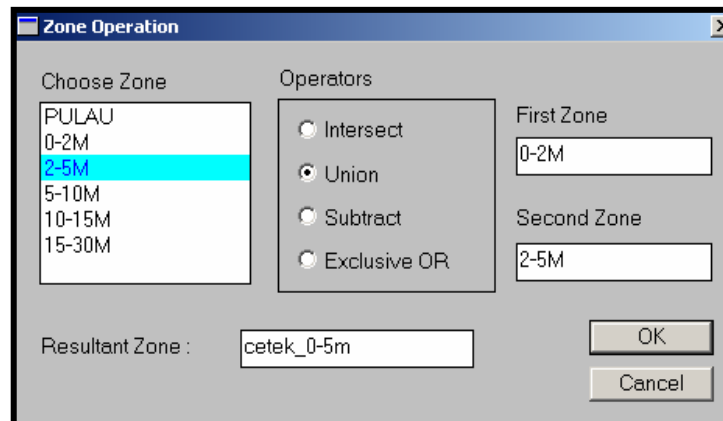


**Figure 5.11:** List of Created Zones



**Figure 5.12:** Result of Created Depth Zones for MAL 5622

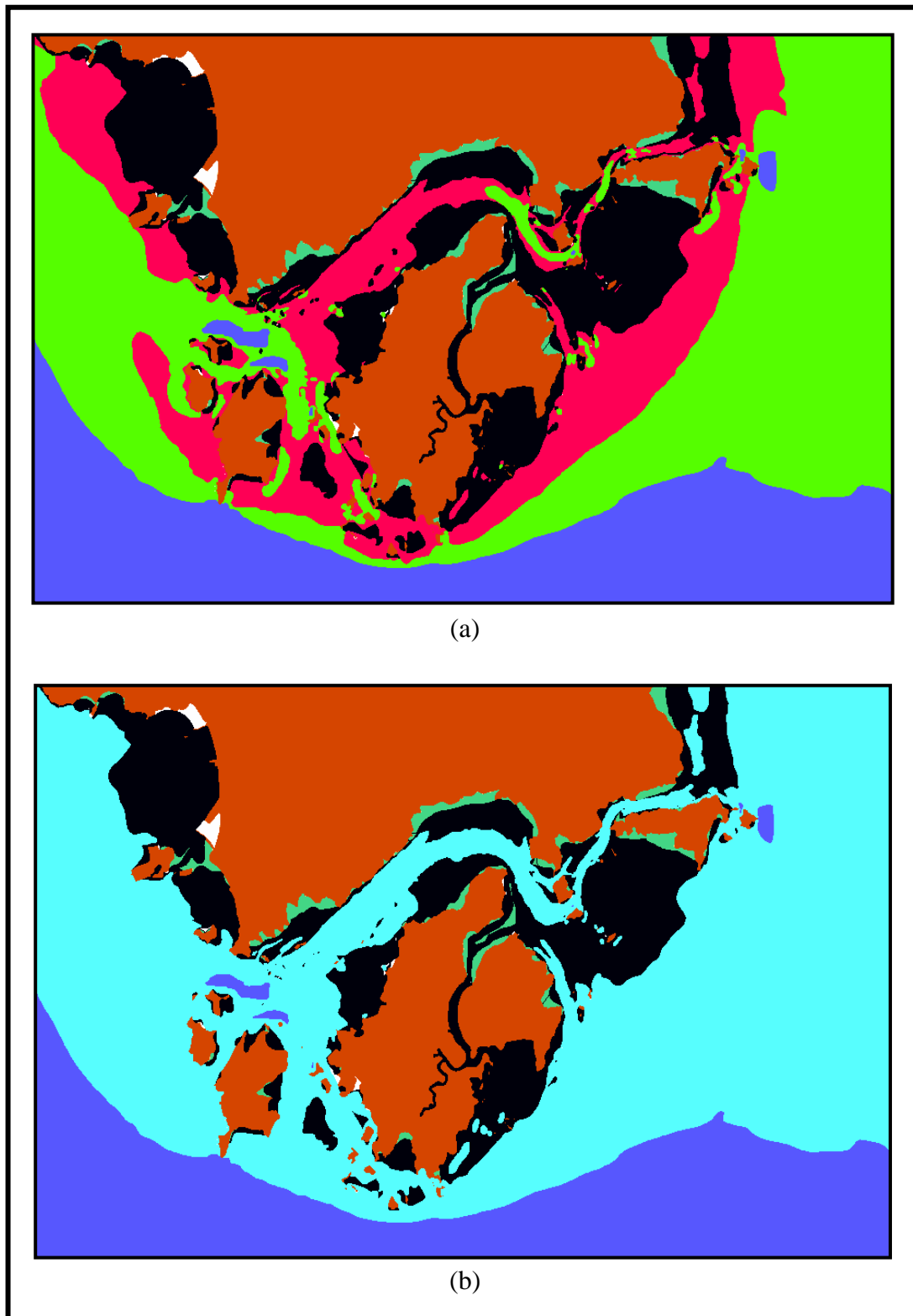
The aim to operate these zones is to merge certain zones to form a new zone. In this study, some of the zones have to be merged such as zone 0-2M and 2-5M to represent the depth value between 0 – 5 meters with the name of CETEK\_0-5M (Figure 5.13). *Union* is the operation to use for merging these two zones.



**Figure 5.13** Operating Zones using Union

Next, the operation repeated for merging zone 5-10M and zone 10-15M to become a new zone called CADANGAN. The result of first operated zone is in black and the second operated zone is in light blue as shown in Figure 5.14. Thus, all small boats and leisure crafts are safe to navigate around zone with light blue with the minimum depth value of 5 meters.



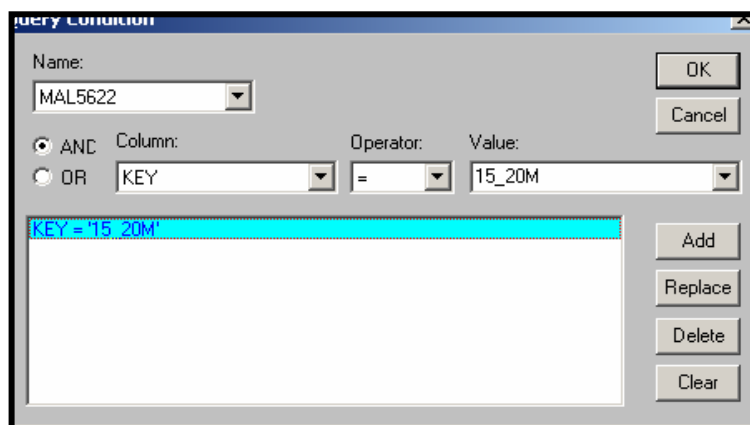


**Figure 5.14** New Zones operated using *Union* (a) Zone CETEK\_0-5M (black)  
(b) Zone CADANGAN (light blue)

## 5.5 Analyse Result for Attribute Query

In this study, all of the attribute tables are formed in Microsoft Excel in the name of *MAL5622.dbf*. After linking the both spatial and attribute data using CARIS Setup, some of the analyses can be done.

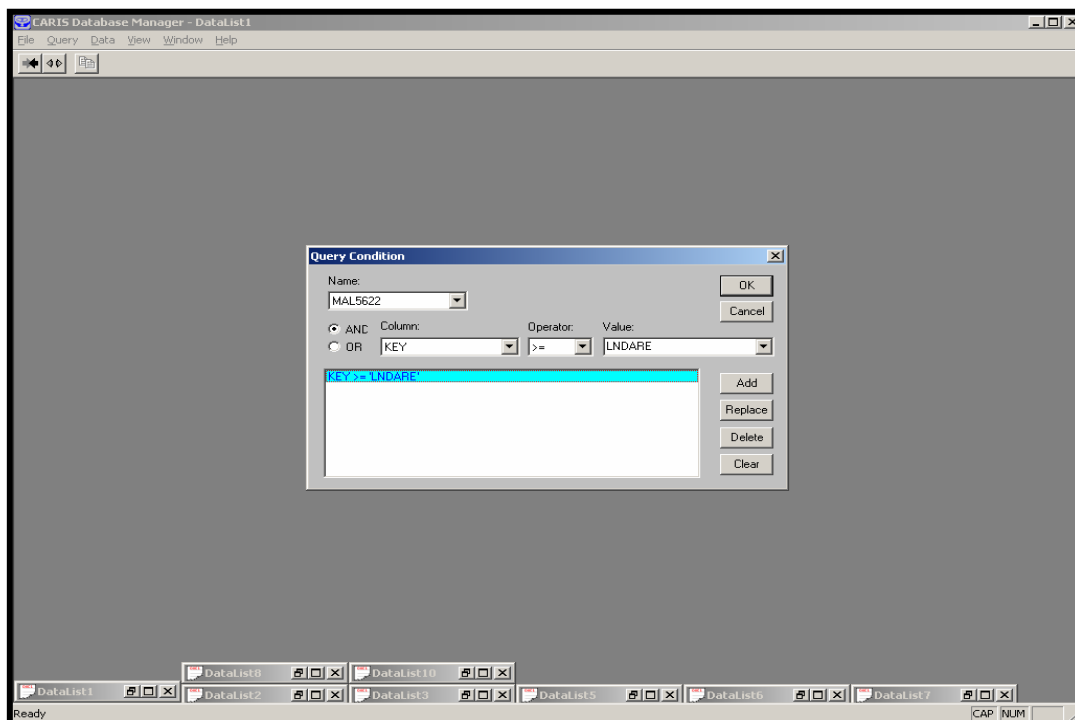
Figure 5.15 show one of the analyses that executed using menu Query Condition in CARIS Database Manager. A test was run to view the total sample polygons between depth intervals of 15m to 20m using 15\_20M as its polygon key. Some tests also executed for other area and the results are shown in **APPENDIX J**.



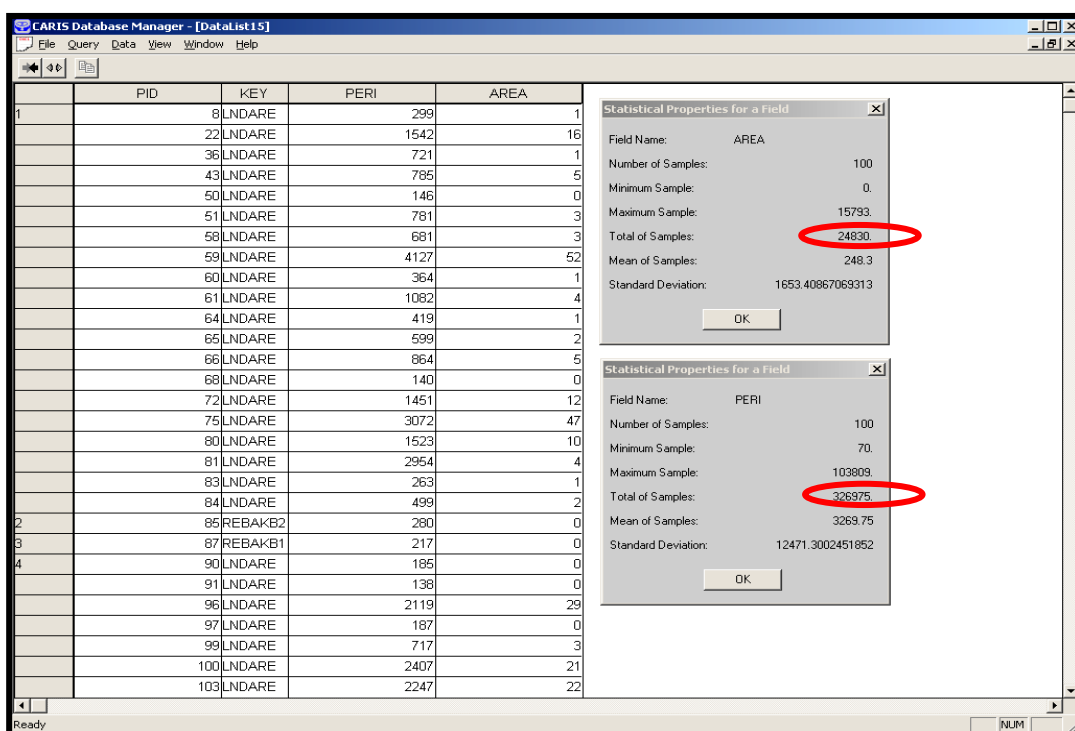
**Figure 5.15:** Analyses using *Query Condition*

Second test is aims to find the area of land in digital nautical chart of MAL 5622. Some of the parameter was inputted as shown in Figure 5.16(a) to find the area of land in the name of LNDARE. Next, program will find the information in *MAL5622.dbf* automatically and list in Data List under CARIS Database Manager. Result of this analyses shows in Figure 5.16(b).

Other than that, result showed in DataList15 has detected the land area using operator '>=' for data LNDARE. It also detected other land area using other keys (e.g. REBAKB1 and REBAKB2) to add into the existing Data List. Thus, a statistic test was executed using menu *Data > Statistic* to obtain the total sample of area and perimeter that involved. Referring to Figure 5.16(b), about 100 samples are involved and the area if 248.3 hectares with the perimeter of 326,975 meters.



(a)

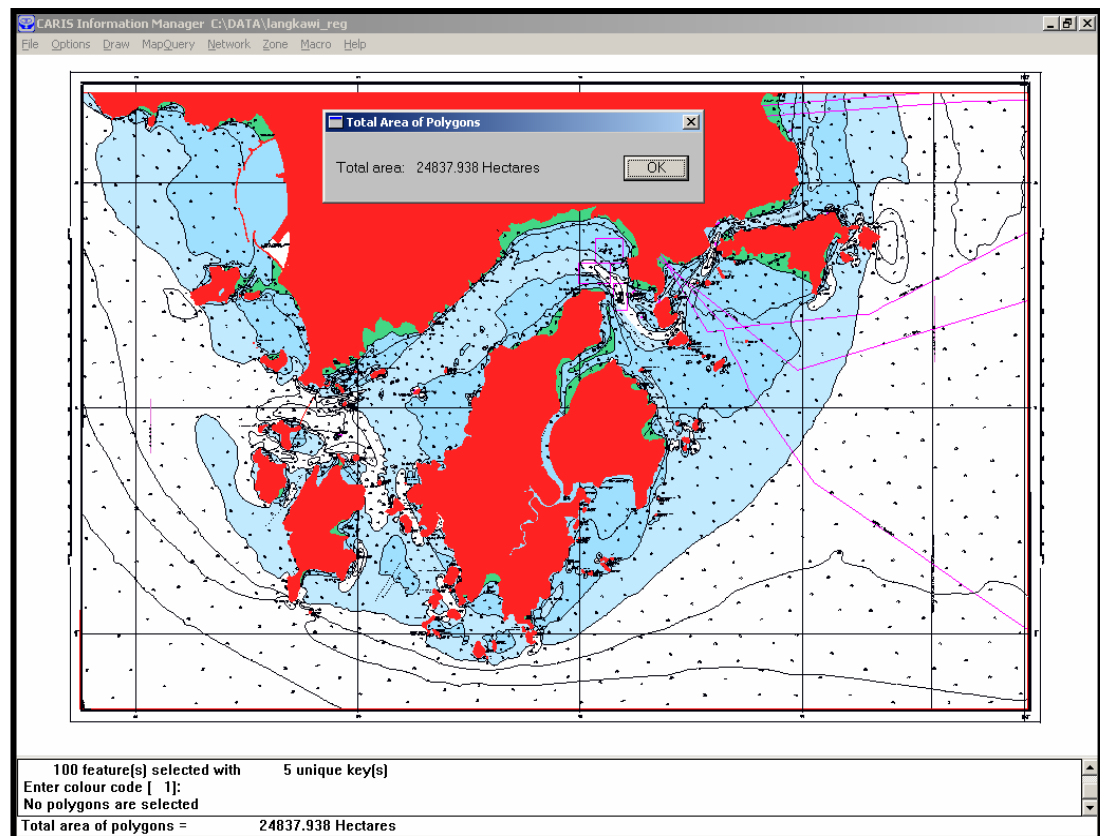


(b)

**Figure 5.16:** CARIS Database Manager (a) Finding Area Information using Query Condition (b) Statistic for Area that Involved

Another test was run using menu *MapQuery > Polygon Area* in CARIS Information Manager to check on the accuracy of the statistic value. Result of the test

is shown in Figure 5.17 with the total land area of 24,837.938 hectares. The result value is about 7 hectares more than the value given by CARIS Database Manager. It is because the value for polygons that kept in \*.dbf for this study are in integer value only.



**Figure 5.18:** Result of Land Area using Menu *Polygon Area*

## 5.6 Conclusion

The result of this study shows that navigators also can do navigational analyses surrounding Port Langkawi as an alternative for them to plan their route efficiently. Using the network analyses, user able to plan speed and period of navigation in short time. In addition, analyses zones also enable user to determine

safety zones for their boats. With that, objective of this study for developing a digital nautical chart in an interactive way for user has been succeed.

## **CHAPTER 6**

### **PHASE II -SYSTEM CONFIGURATION AND WEB BUILDING**

#### **6.1 Background**

After obtaining the result of digital nautical chart for small boats and leisure crafts, it will be more convenient for user to receive these data through Web. Thus, some of the procedures have to be executed for building a Web application – Nautical –WebGIS to publish digital nautical chart on Web. In the preparation for Web building, system configuration has to be involved.

System configuration is to install the software that used for system creation, besides that it is also needed to configure the server for web application. It is recommended to set up a password during server configuration, thus the progress system will be in protected. After configure the software, the Web can be developed. The Web must have a user-friendly interface to help user in finding information. In order to have a user-friendly interface, it needed to be customized using programming languages.

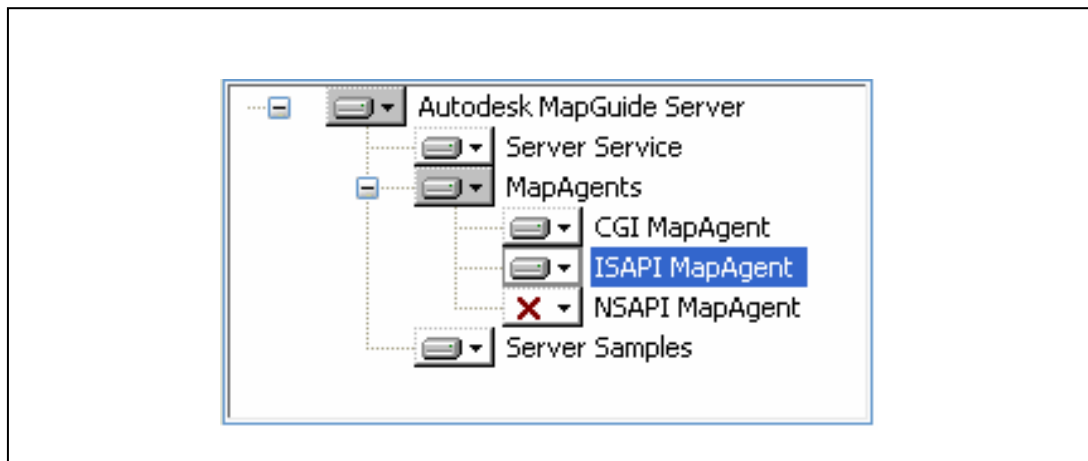
## **6.2 System Configuration**

To build a Web application, researcher needs to install three servers, which are IIS Internet Information Services acts as Web server, Autodesk MapGuide server act as application server and also Map Server (MapAgent). The Map Server will act as a medium between application server and Web Server for sending requests. In the phrase of systems configuration, there are some procedures such as Installation of software and server, server configuration, data format conversion, database configuration, loading data spatial and database.

### **6.2.1 Installation of Software and Server**

The Internet Information Services (IIS) is considered as software service to support the development of Web application, configuration and manage with other Internet functions. The IIS was installed in the Control Panel using Integrated Service Pack 4 in Window 2000 Professional CD.

After installed the IIS, researcher needed to install the application server and also the map server. Thus, Autodesk MapGuide 6.3 was installed with three components; there were MapGuide server 6.3, MapGuide Author 6.3 and also MapGuide Viewer 6.3. Some of the needed utilities also installed. When the MapGuide server was installing, there would be a wizard that showing the suitable MapAgent to be used for developers (Figure 6.1).



**Figure 6.1:** Choosing the MapAgent from wizard installation

For this research, the CGI (Common Gateway Interface) and ISAPI (Internet Server Application Programming Interface) would be chose instead of NSAPI (Netscape Server API). CGI is works with any kinds of Web server and it can be installed easily. ISAPI can be load by IIS with a faster performance compare with CGI. And, the NSAPI is works with Netscape Enterprise Server with almost same functions with ISAPI. NSAPI was not selected during installation because this research used the Internet Explorer 6.0 as is web browser. Both of the MapAgent that installed would act as Map Server between IIS and Autodesk MapGuide Server.

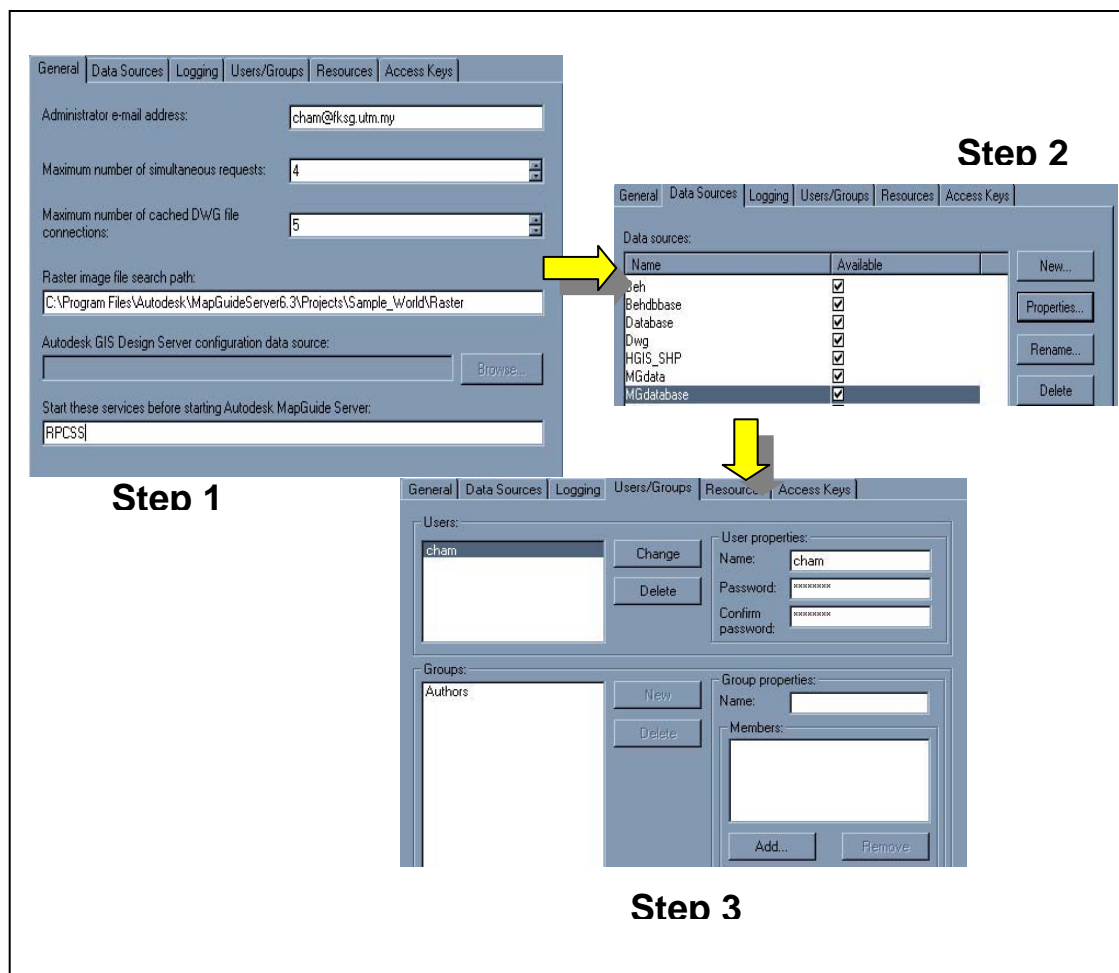
### 6.2.2 Servers Configuration

After the IIS has been installed, a virtual directory needed to be created in IIS in order to present the spatial data in Internet. For this research, the virtual directory that has been created and the URL is <http://localhost/mgweb/>. Therefore, all of the websites or scripts that developed would be saved in this directory for publishing. Furthermore, the



MapAgent also have to be confirmed that it is located in IIS. The URL of MapAgent is <http://localhost/scripts/mapagent.exe> for this project.

For the Autodesk MapGuide Server, there are some values have to be defined in the properties wizard such as setting a new path for the source of data, setting a password for security of project and others. The steps of Autodesk MapGuide Server configuration are as Figure 6.2.



**Figure 6.2:** Process of Autodesk MapGuide Server Configuration

From the Figure 6.2, the step one is mainly for developer to add in the email address and some limitation of data path. Then, the step two is for developer to define the

location of data in computer to be used for the project, it can be defined from the properties button. And, there are varies type of data provider can be chose such as Spatial Data Provider for SDF (Spatial Data Format), Spatial Data Provider for SHP, Connectivity Service Provider and others. There are two data providers were created for this research, which are Autodesk Spatial Data Provider for SDF for the spatial data and Microsoft OLE DB Provider for ODBC Drivers. The last step is to set up the password and groups or users can create it.

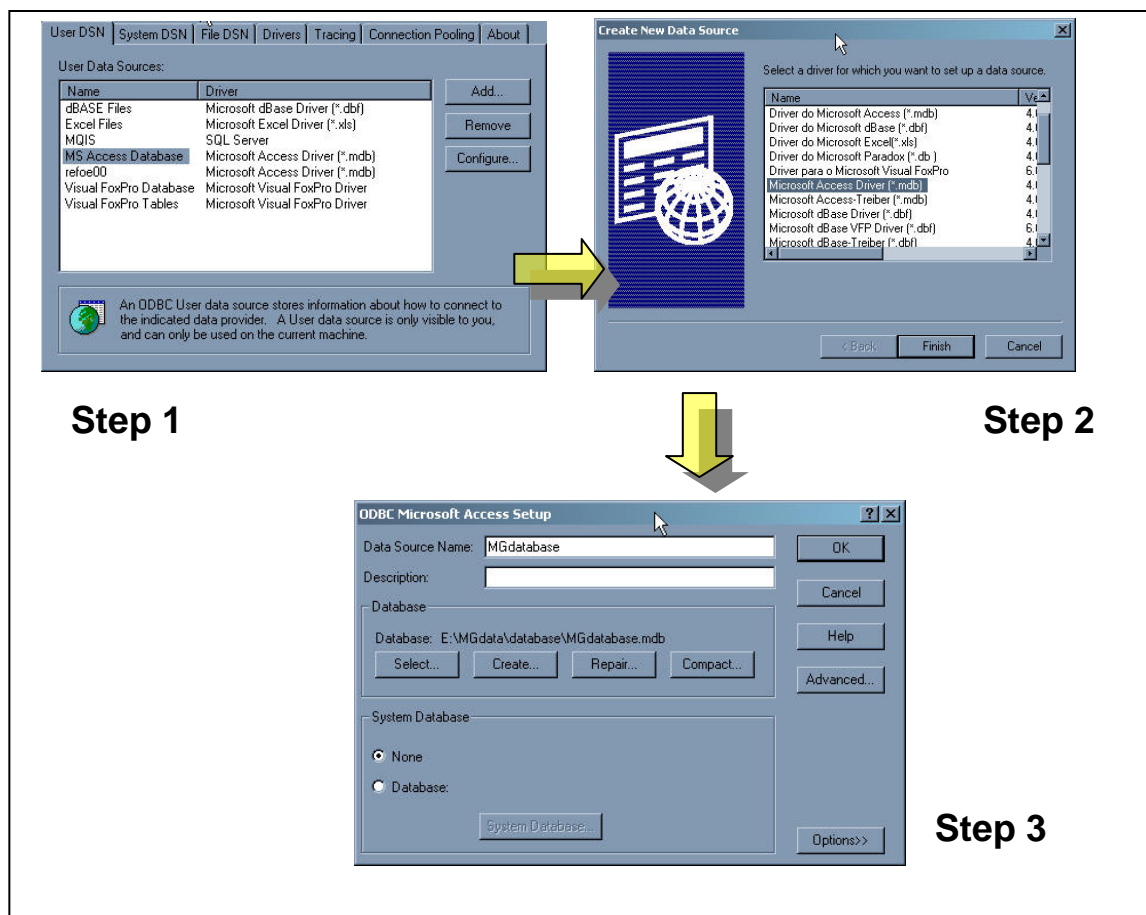
### **6.2.3 Data Format Conversion**

The CARIS had convert into coverage format after transforming its projection into RSO in ArcGIS 8.3. For Autodesk MapGuide 6.3, it is recommended to use data format in SDF because there would be no function limitation for this kind of data format in. In order to convert the data format, Autodesk MapGuide SDF Loader is needed. Autodesk MapGuide SDF Loader is a command-line utility that converts map data from a variety of GIS data file formats to binary-format Spatial Data Files (SDF). Autodesk MapGuide Server reads and serves SDF files to Autodesk MapGuide Author and Autodesk MapGuide Viewer.

The data format conversion is run in MS DOS Prompt. The data file will be separate to be converted in form of spatial and attribute. For the spatial data will be convert into SDF format whereas the attribute would be convert into CSV (Microsoft Excel Comma Separated Values Files). The converted SDF can be viewed in Autodesk MapGuide Author for further development of research. In contrast, converted CSV files for each layer have to open in Microsoft Access for combining all the tables and saved them as MGdatabase.mdb.

## 6.2.4 Loading Data Spatial and Database

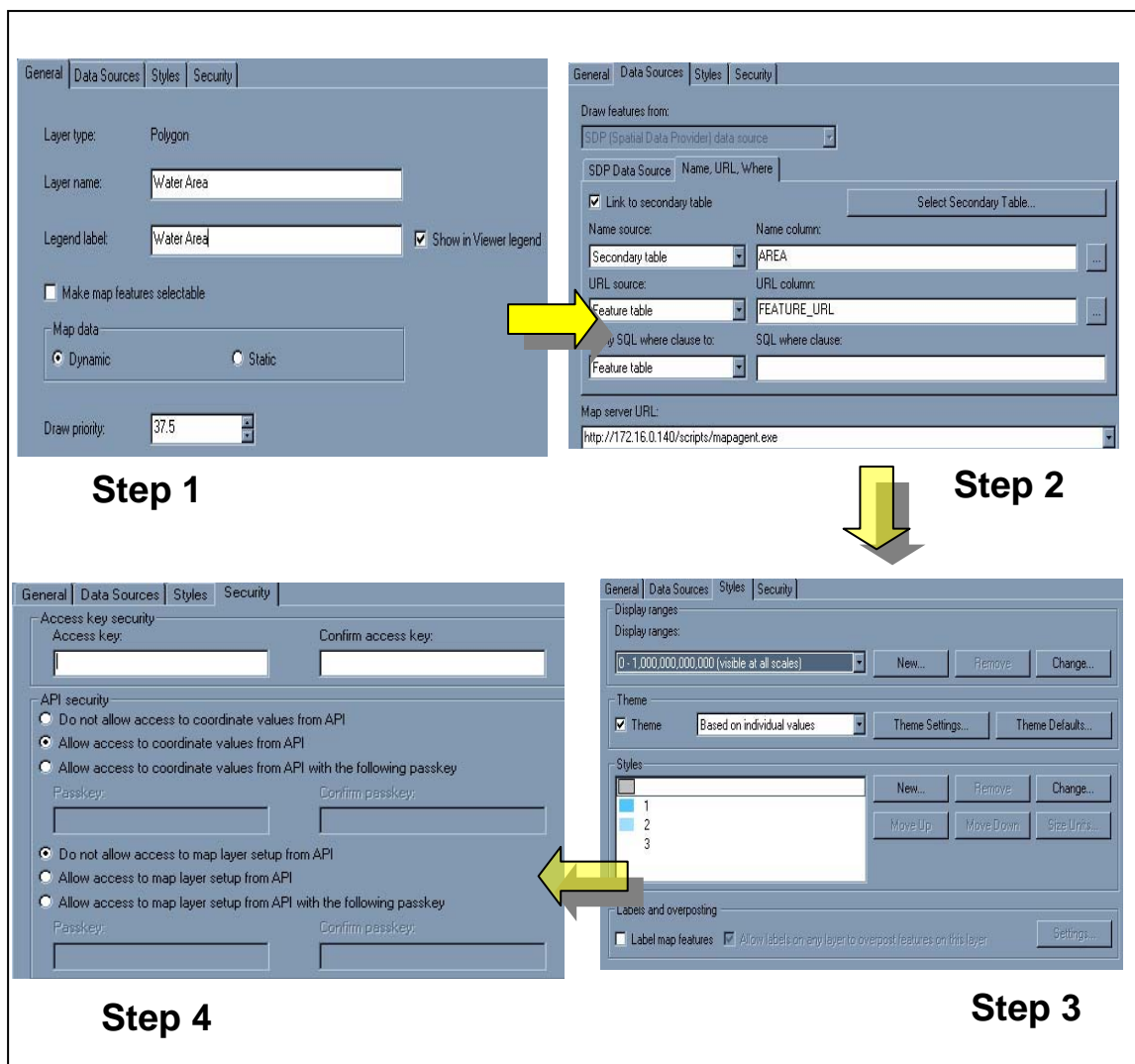
Before the data to be loaded in the Autodesk MapGuide Author, the MGdatabase.mdb has to be configured in the ODBC data sources and drivers. The configuration of database is to ensure database connectivity between networks would be worked. The steps for ODBC configuration are shown in Figure 6.3.



**Figure 6.3:** Process of database configuration

The Step one and two in the Figure 6.3 is to define the data types of the database. When it comes to step 3, the path of the database needs to define as well as the data source name for linking.

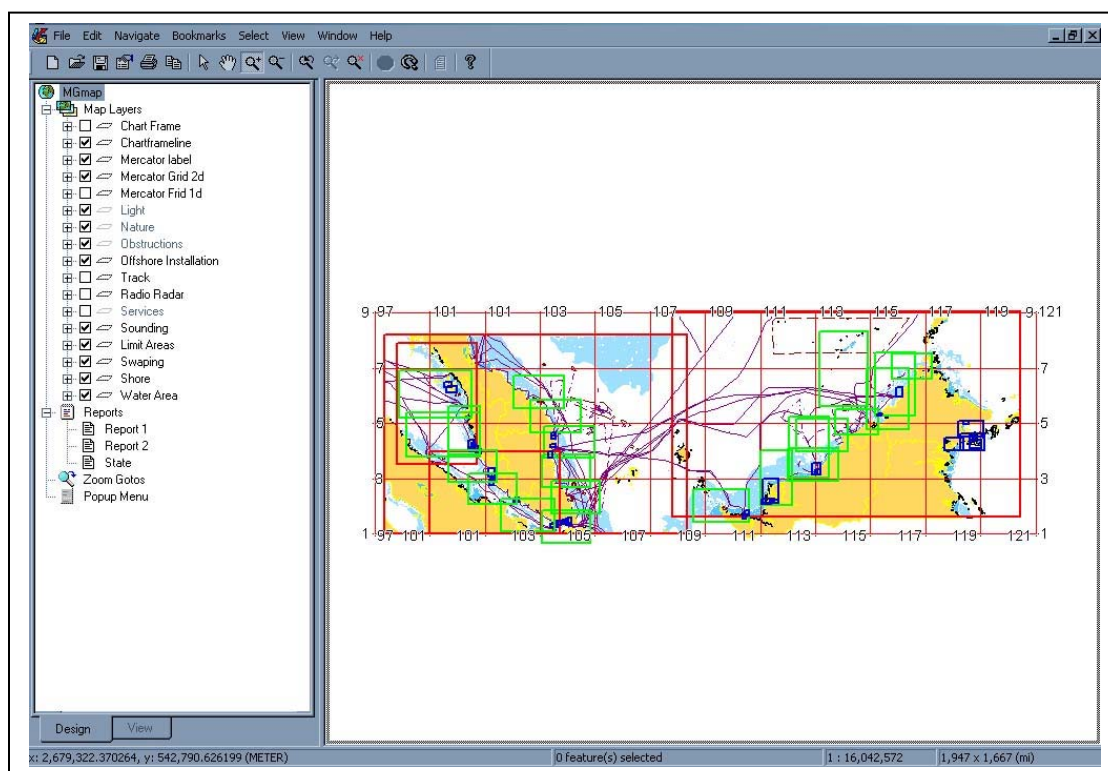
After the database and the data spatial have been prepared well, all of the layers would be loaded in Autodesk MapGuide Author and save it as a MWF (Map Windows File). Before the MWF file completed, there are some configuration needed for each layer in the Map Window Properties and Map Layer Properties. For the Map Window Properties, the projection of spatial data is defined as Arbitrary X-Y Coordinate Projection. However, the steps for Layers configuration are shown in Figure 6.4.



**Figure 6.4:** Process of Map Layers configuration

The Step one in 6.4 is to name the layer name and whether or not it want to be shown in the legend. Next, the step two is to link the layer with the table in Access database. It can be linked with a secondary table or feature table. At the below of this window, there is a line to set the location of MapAgent. The location of MapAgent must be set as the same location in the IIS so that the chart will be shown online. For this research, the URL of MapAgent is <http://localhost/scripts/mapagent.exe>. The next step is to define the style of layer to be presented and also the label for layers. The final step for the Map Layer Properties configuration is to set the layers and API security. Each of the layers can own a password to secure the privacy of information.

The result of the layers presented in Autodesk MapGuide Author 6.3 is shown in Figure 6.5 with a list layers legend and and different styles spatial data. This combination of layers will be saved as Map.mwf for development of Web application.



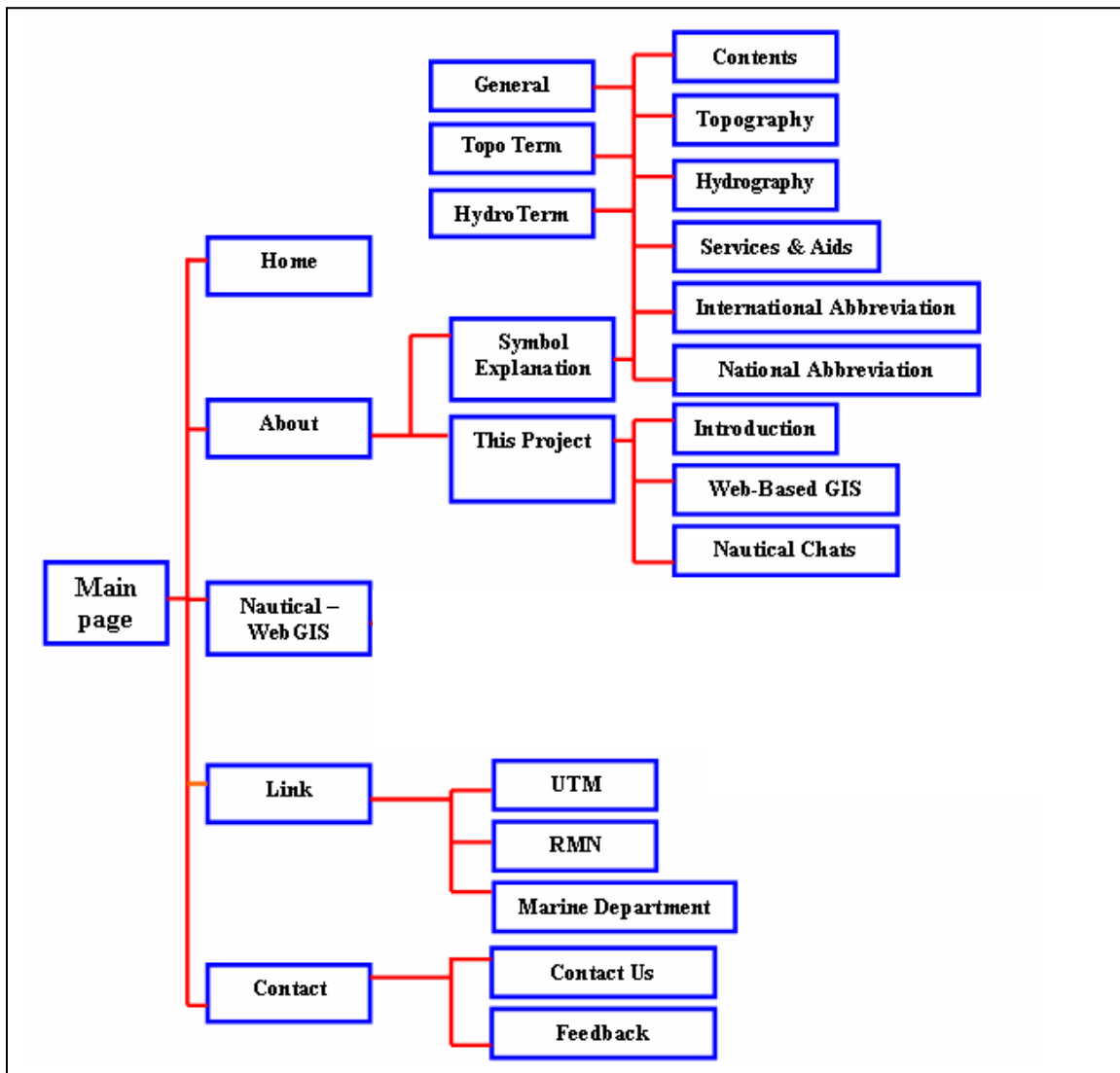
**Figure 6.5:** Map Window in Autodesk MapGuide Author .

## **6.3 Web Building**

When all of the data are well prepared, it is time to build up the Web for data presentation. This phase is to determine the final presentation of Nautical – WebGIS in a user friendly way. In addition, the Web that would be developed has to achieve the objective of this research. Therefore, it is needed to start with Web design for planning how to present all the information. Other than that, development of Nautical –WebGIS is included in this phase.

### **6.3.1 Web Design**

In the Nautical – WebGIS, the interactive between the end user with the Web application have to be worked smoothly. Thus, some issues will be focused to build a consistent design, such as presentation for map and information, text, colour, structure of content and visualization for the Web. Figure 6.6 shows the sitemap design for the Web structure.



**Figure 6.6:** Site map for Nautical – WebGIS

In Figure 6.6, it shows the structure of the Website has been divided to five sections. These five sections are Home, About, Nautical – WebGIS, Link and also Contact. The Home is actually same with the main page. In About, there are two web pages, which are symbol explanation and this project. The symbol explanation is pages to descript the symbols that collected in MAL 1 by categorized to 3 parts according to its code. In the other hand, this project is to explain the research in details. For the Nautical –

WebGIS, user will be able to do some analyses on digital charts. The other two pages are link and contact. Link is enable user to go to related Website and the Contact is to receive feedback from users. Furthermore, the contact information also would be stated in this page.

### **6.3.2 Development of Nautical –WebGIS**

The Website for Nautical–WebGIS has been divided to different sections that shown in Figure 5.6. Microsoft Office FrontPage 2003 is used for developing HTML pages such as Home, Feedback, This Project, Symbol Explanation and others. These pages can provide information to end-user in a simple way. Some of the components that can present through the HTML are table, picture, button, icon, text and animation.

The static pages are written in HTML language whereas the dynamic pages are in ASP, VBScript, JScript and Autodesk MapGuide Viewer API. In order to build up a complete and user-friendly Website for Nautical–WebGIS, some dynamic pages are included likes dynamic map, security module and also interactive query.

#### **6.3.2.1 Development of Dynamic Map**

During the software configuration, the output of spatial data has been saved as Map Window File (MWF), which is MGmap.mwf. The file will need to be presented in Autodesk MapGuide Viewer API and there are 3 types of viewer API, which are



Autodesk MapGuide Viewer Plug-in, Autodesk MapGuide viewer ActiveX Control and Autodesk MapGuide Viewer Java Edition. Due to the web browser that in use is Microsoft Internet Explorer, thus the Autodesk MapGuide Viewer ActiveX Control is used for presenting the interactive map.

The process of displaying a map involves linking to or embedding the map in a Web page. In this research, the map is displayed by embedding it in HTML page. There is a list of parameters that control the way the map is displayed when it is embedded in an HTML. The examples of parameters are MapScale, MapWidth, Coordinates, Units, ToolBar, StatusBar, URL, LayersViewWidth and others. In the URL, the IP address and the directory of the *map.mwf* need to define for presenting the output of spatial data.

Autodesk MapGuide provides a default map window with some default toolbars for map viewer API. In developing the Nautical – WebGIS, some of the basic map functionalities such as Select, Pan, Zoom In, Zoom Out, Zoom Previous, Zoom Select, Full Map and Print are customized to be shown in dynamic graphic. In this way, the Web page could be displayed attractively. The script of the dynamic map is shown in **Appendix K**.

#### **6.3.2.2 Development of Interactive Query**

Based on the result of need assessment that have be done, there are 2 main layers are needed for query function. These two layers are Malaysian nautical charts and Notice to Mariners. However, the details of information for other layers are shown in the report function.

The query functions for Malaysian nautical charts have been divided to two parts, which are query by code and query by state. Whereas, the query functions for Notice to Mariners are query by code and query by charts. Through this separation of query, users are able to obtain the needed information easily. Besides, a zoom go to function also would be shown in the result query, so that users can view the location of spatial data directly from the result query.

The script for the result of interactive is shown in **Appendix K**.

## **6.4 Conclusion**

In the system configuration, there are 3 servers are installed for this research continuously, which are IIS Web server, MapAgent and the Autodesk MapGuide application server. Other than that, both data spatial and database that have been fully completed also need to configure in the server. The data spatial was configured through the Autodesk MapGuide Author and the database is configured in the ODBC data sources and drivers.

The designing of the Web application for this research has been discussed in two kinds of development, which are development of dynamic map and development of interactive query. Each of the development is playing an important role to success the research.

## **CHAPTER 7**

### **PHASE II - EVALUATION FOR NAUTICAL – WEBGIS**

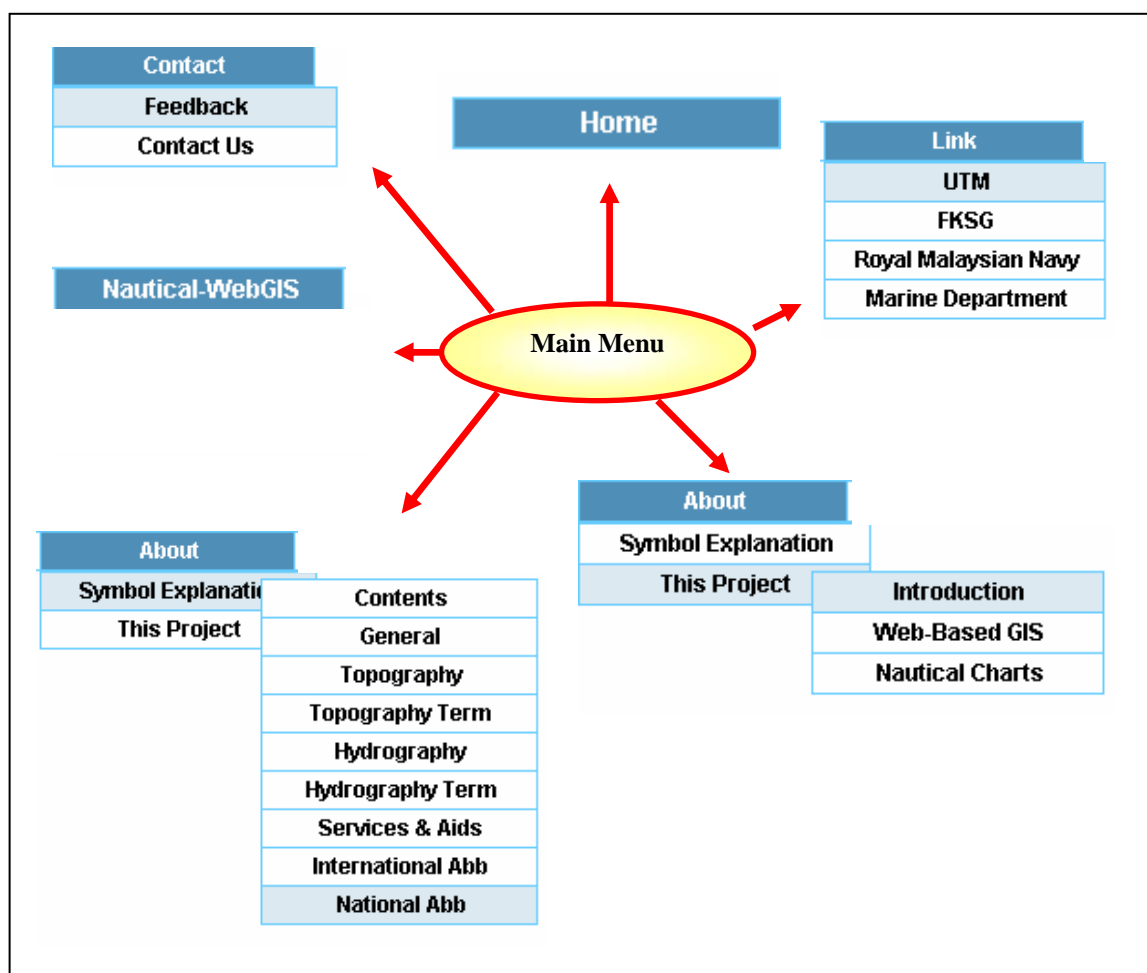
#### **7.1 Background**

The development of Nautical – WebGIS is mainly for providing updated nautical charts information as well as the latest Notices to Mariners to the end users through Web platform. Furthermore, the second objective of this research is to test and evaluate the result of application based on its performance and the opinion from the users. Therefore, testing and evaluate from both researcher and end users have to be done for ensuring the variety interfaces of the Website are user-friendly.

#### **7.2 Website for Nautical – WebGIS**

The sitemap of the Website has been discussed in chapter 6. Thus, the result of the Website can be divided to six main parts; there are Home, About – Symbol Explanation, About – This Project, Nautical – WebGIS, Link and Contact (Figure 7.1).

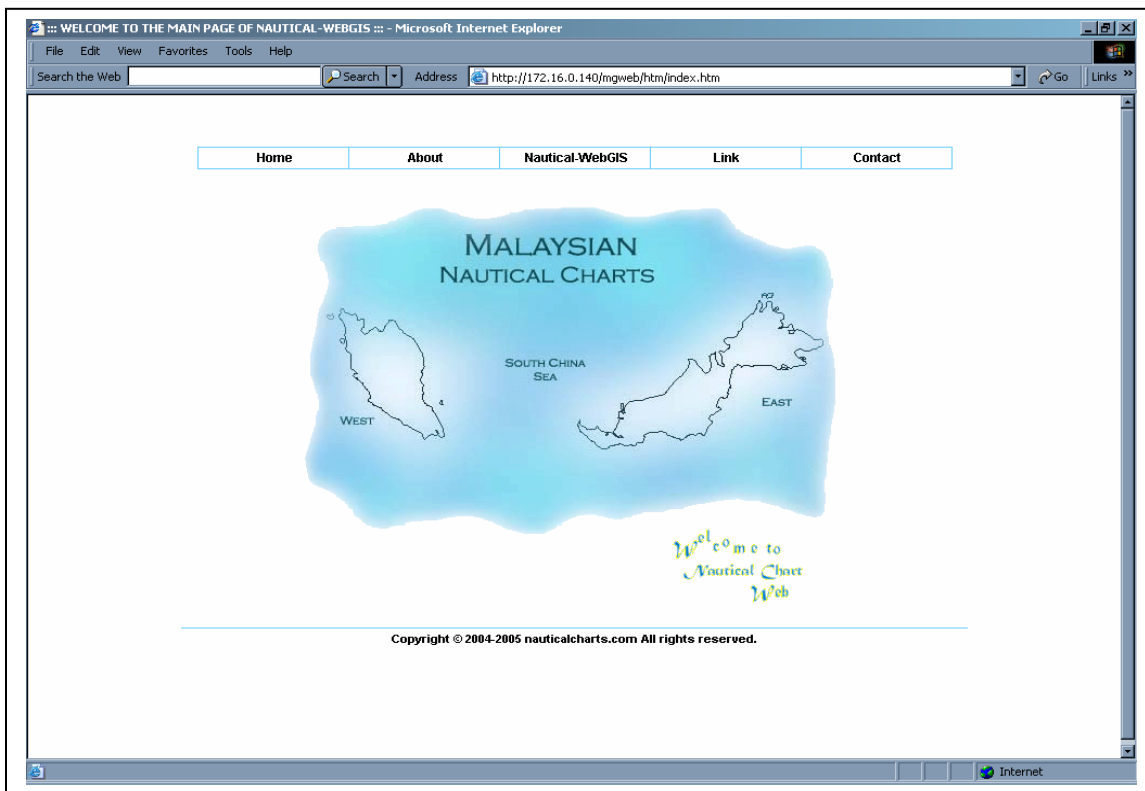
All of these parts can be categorized into four types of interface, which are interface of Website Information, interface of Map Display, interface of Authorization and interface of Query Functions. Most of the Web pages for the Website Information are developed in HTML. Others web pages are in ASP, VBScript and Jscript.



**Figure 7.1:** Six main parts of the Website

### 7.2.1 Interface of Web Information

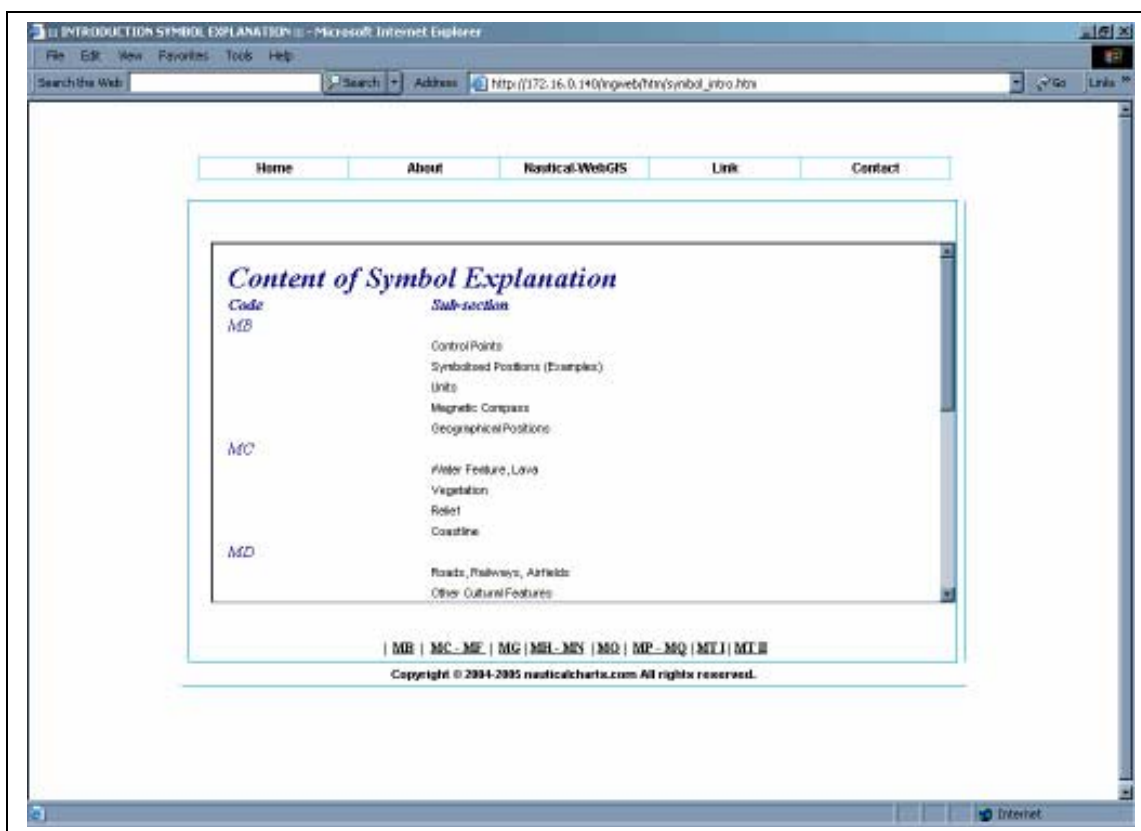
In this research, most of the Web pages are providing the Web information, such as Home, About – Symbol Explanation, About – This Project, Link and Contact. The main page for the Web site (Home) has a list of the menu bar at the top page to give an easy way of selection. (Figure 7.2)



**Figure 7.2:** Home – main page of the Website

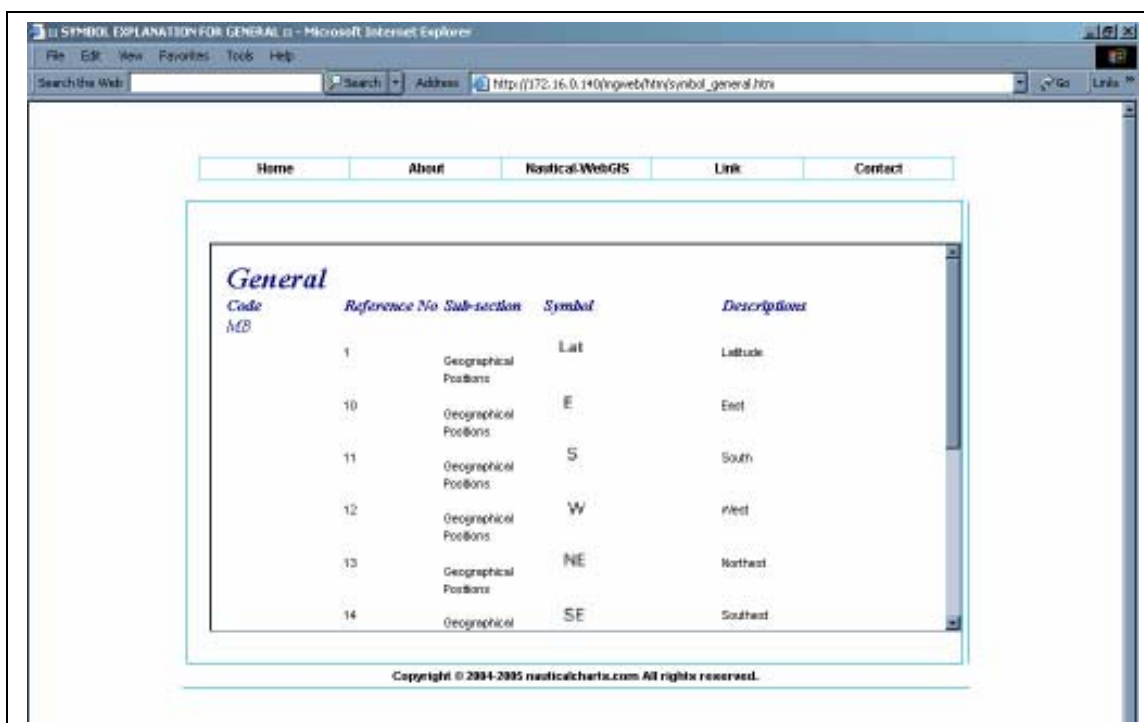
#### 7.2.1.1 Interface of About – Symbol Explanation

For the About – Symbol Explanation, there is a list of symbol types based on MAL 1 shows in the Website. The first column in About – Symbol Explanation is the contents (Figure 7.3). It shows the symbol types according to their code (MA – MU).

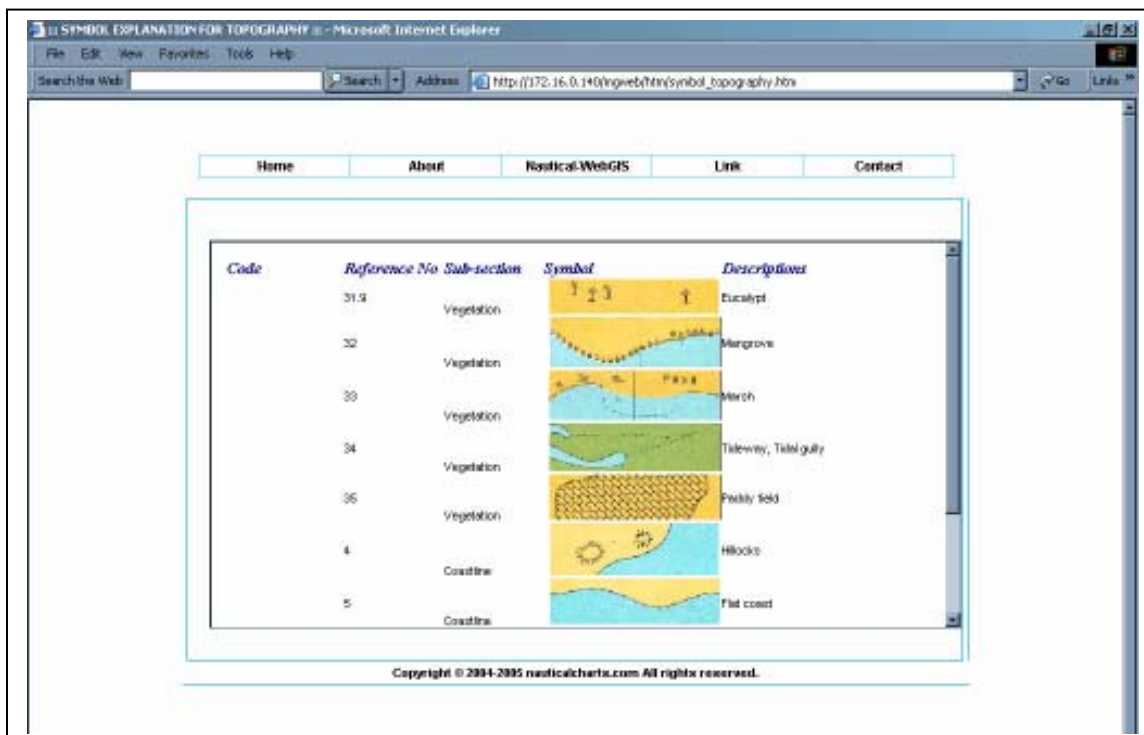


**Figure 7.3:** Symbol Explanation – Content of the symbol types according code

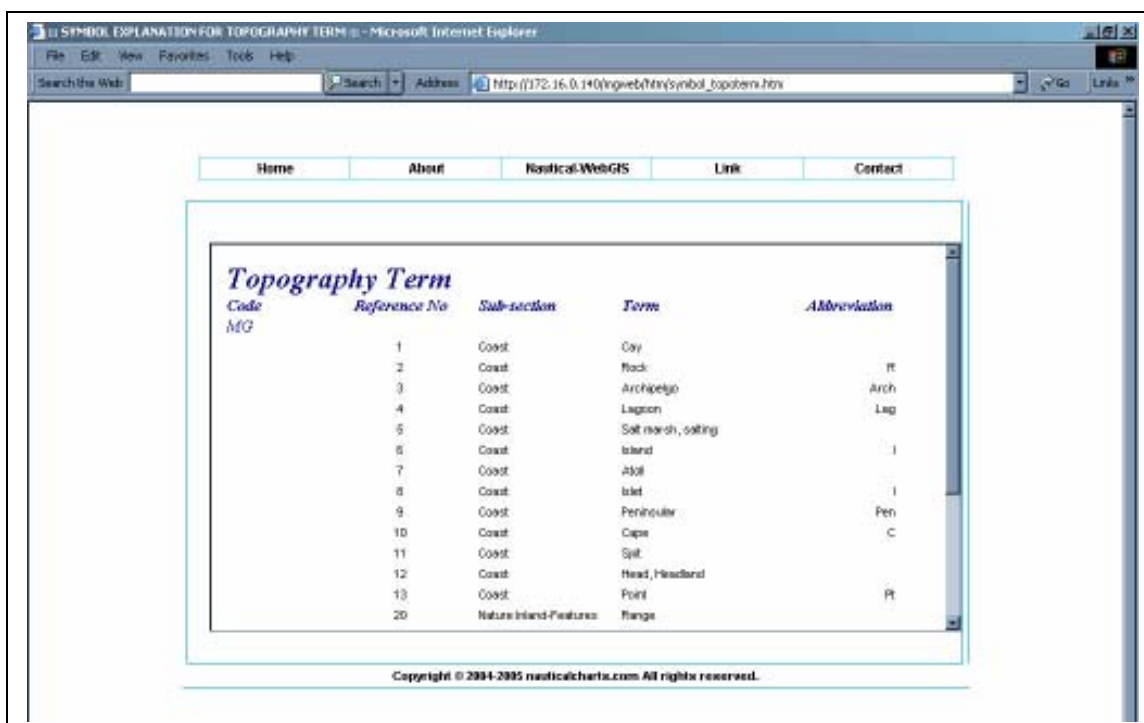
Those symbols have been categorized to General, Topography, Hydrography, Services and Aids, and Abbreviation. The General symbols (Figure 7.4) included positions, distance, direction and also compass. The Topography (Figure 7.5) has the descriptions for natural features, cultural features, landmarks, ports and also topography terms (Figure 7.6). In the hydrography page (Figure 7.7), there are tides and currents, depths, natural of seabeds, obstructions, offshore installations, tracks, areas and hydrographic terms (Figure 7.8). Some symbols like lights, buoys, beacons, radar, radios, small craft facilities and services are categorized in Services and Aids page (Figure 7.9). The last symbols types are Abbreviations indexes; it has been divided to the International Abbreviation page (Figure 7.10) and National Abbreviation page (Figure 7.11).



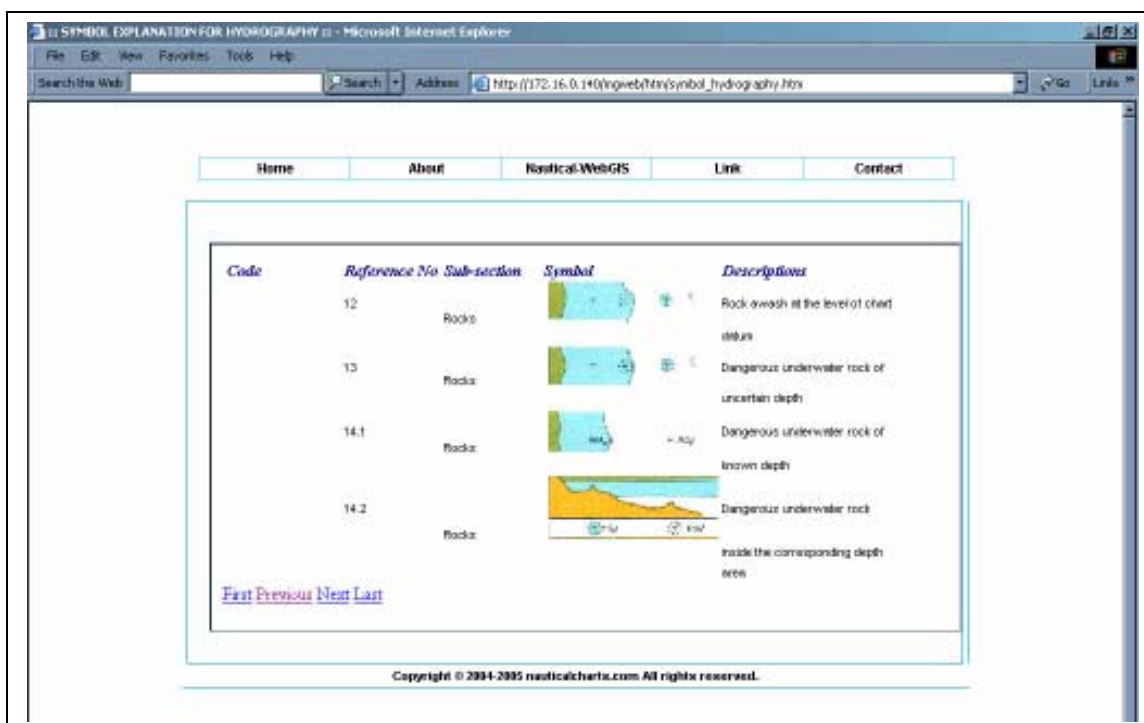
**Figure 7.4:** Symbol Explanation – General



**Figure 7.5:** Symbol Explanation – Topography

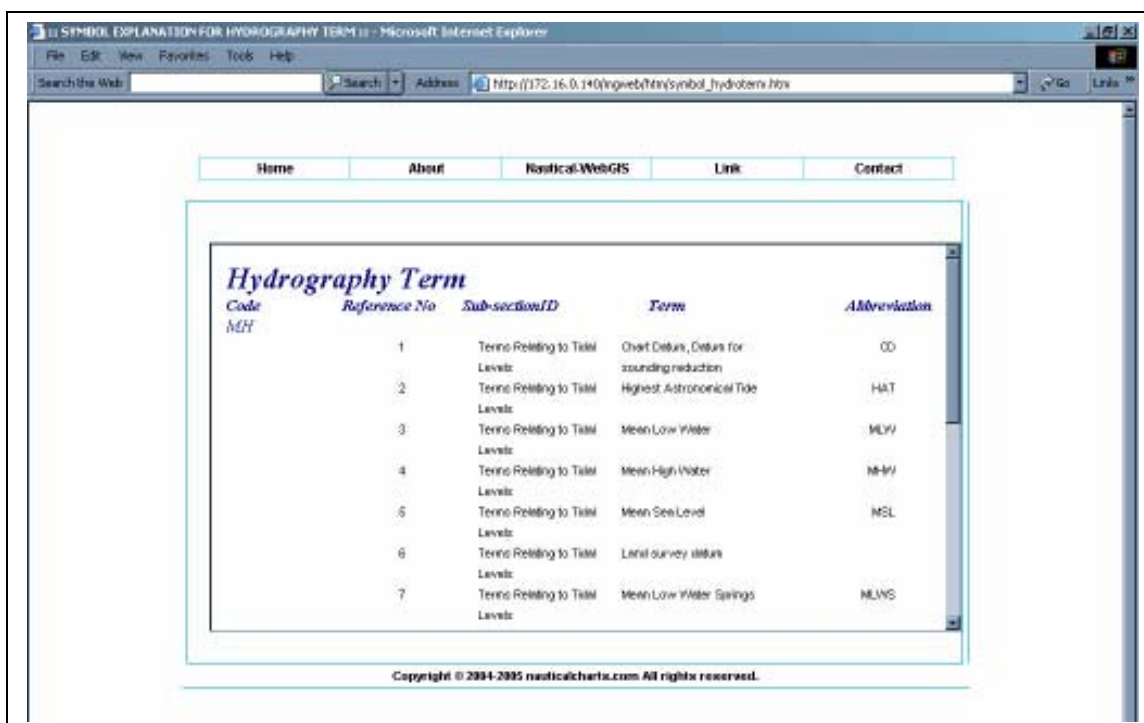


**Figure 7.6:** Symbol Explanation – Topography Term

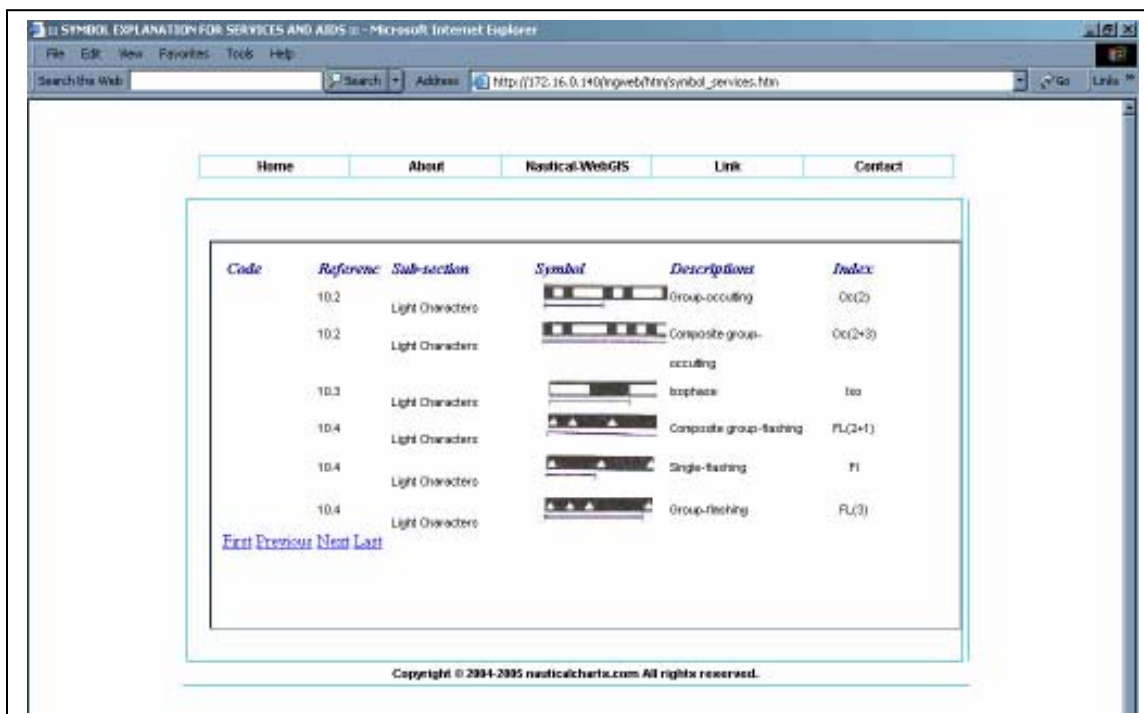


**Figure 7.7:** Symbol Explanation – Hydrography





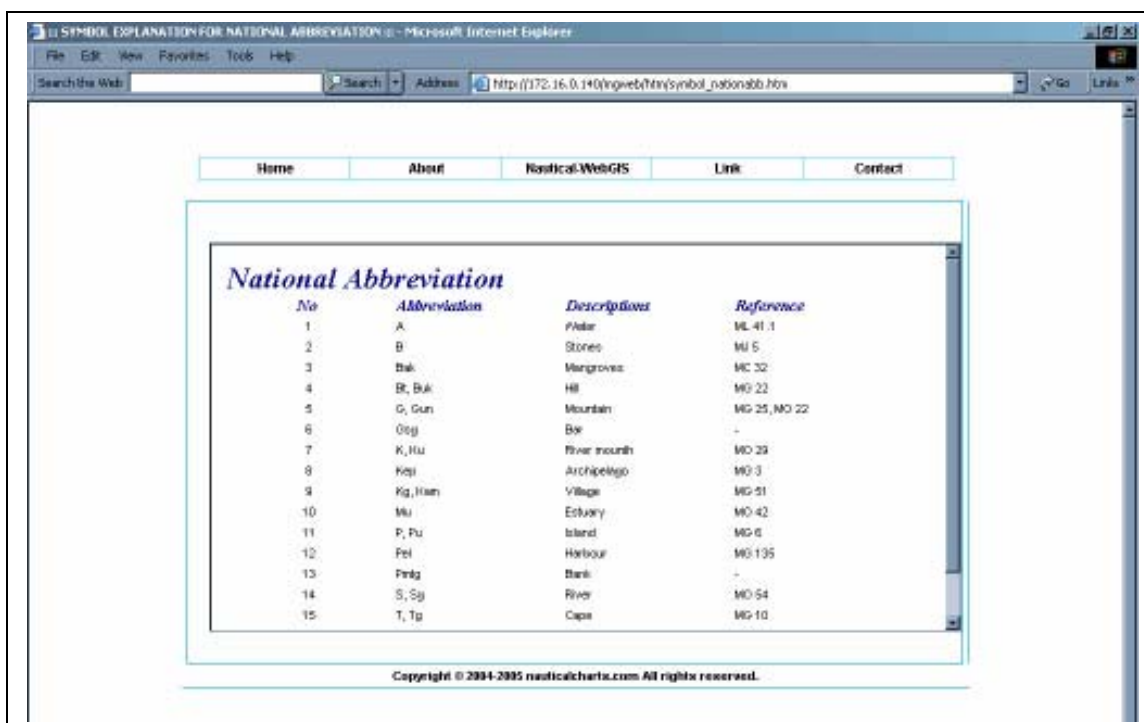
**Figure 7.8:** Symbol Explanation – Hydrography Term



**Figure 7.9:** Symbol Explanation – Services and Aids



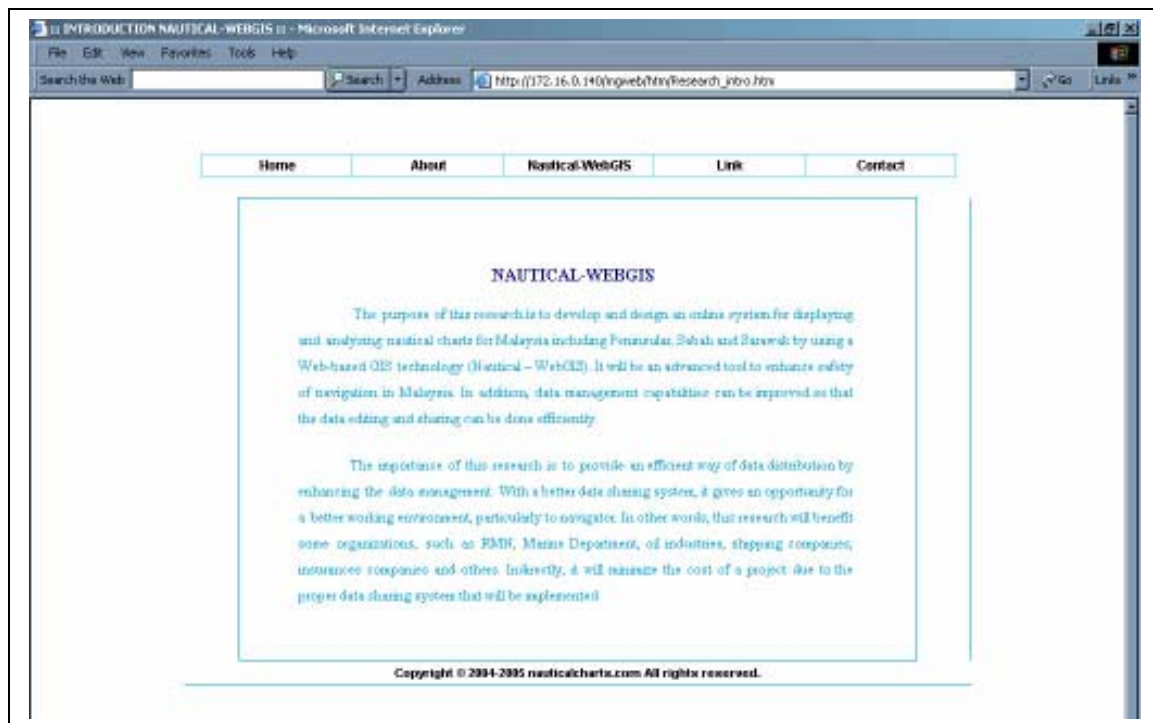
**Figure 7.10:** Symbol Explanation – International Abbreviation



**Figure 7.11:** Symbol Explanation – National Abbreviation

### 7.2.1.2 Interface of About – This Project

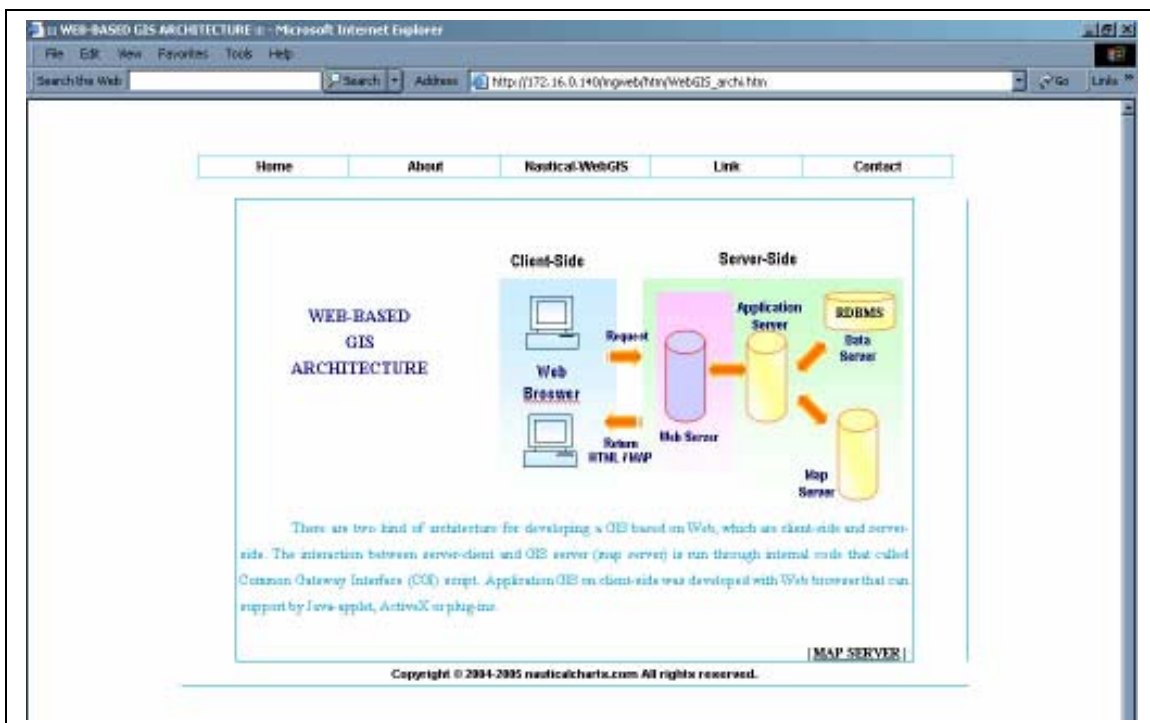
The Web pages for about – This Project are mainly describing some issues that are related with this research. It has been divided into Introduction (Figure 7.12), the explanation of Web – Based GIS as well as Nautical Charts. In the Web – Based GIS (Figure 7.13), users are able to view details through the link below. The explanation has been separated to Web – Based GIS Architecture (Figure 7.14) and Map Server (Figure 7.15). However, the development of Nautical Charting (Figure 7.16) contents three sub sections, which are Earliest Chart (Figure 7.17), Nautical Chart (Figure 7.18) and Electronic Chart (Figure 7.19).



**Figure 7.12:** This Project – Introduction about Nautical WEBGIS



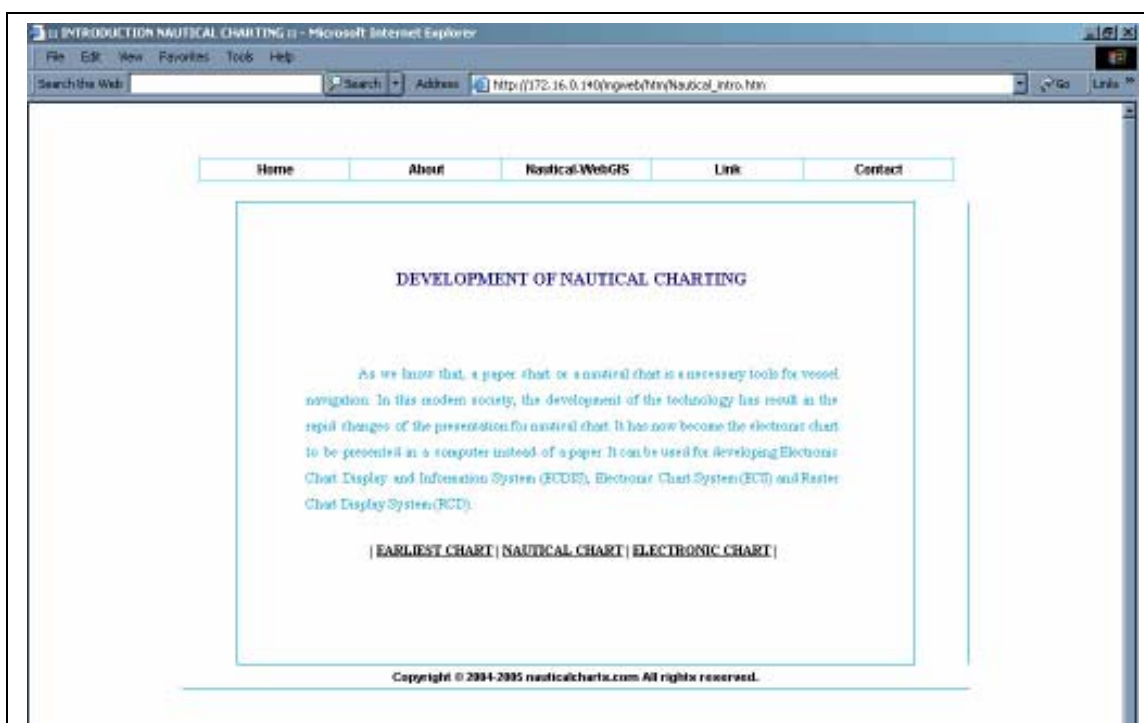
**Figure 7.13:** This Project – Web-Based GIS



**Figure 7.14:** This Project – Web-Based GIS Architecture



**Figure 7.15:** This Project – Map Server



**Figure 7.16:** This Project – Development of Nautical Charting

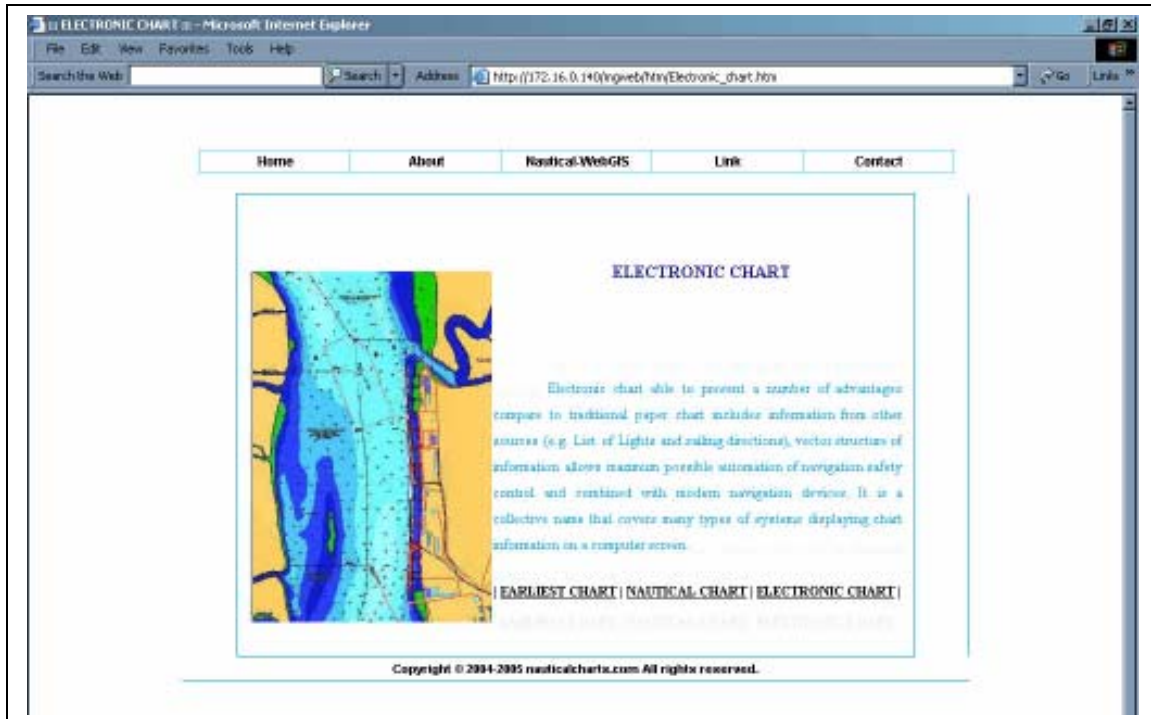


**Figure 7.17:** This Project – Earliest Chart



**Figure 7.18:** This Project – Nautical Chart

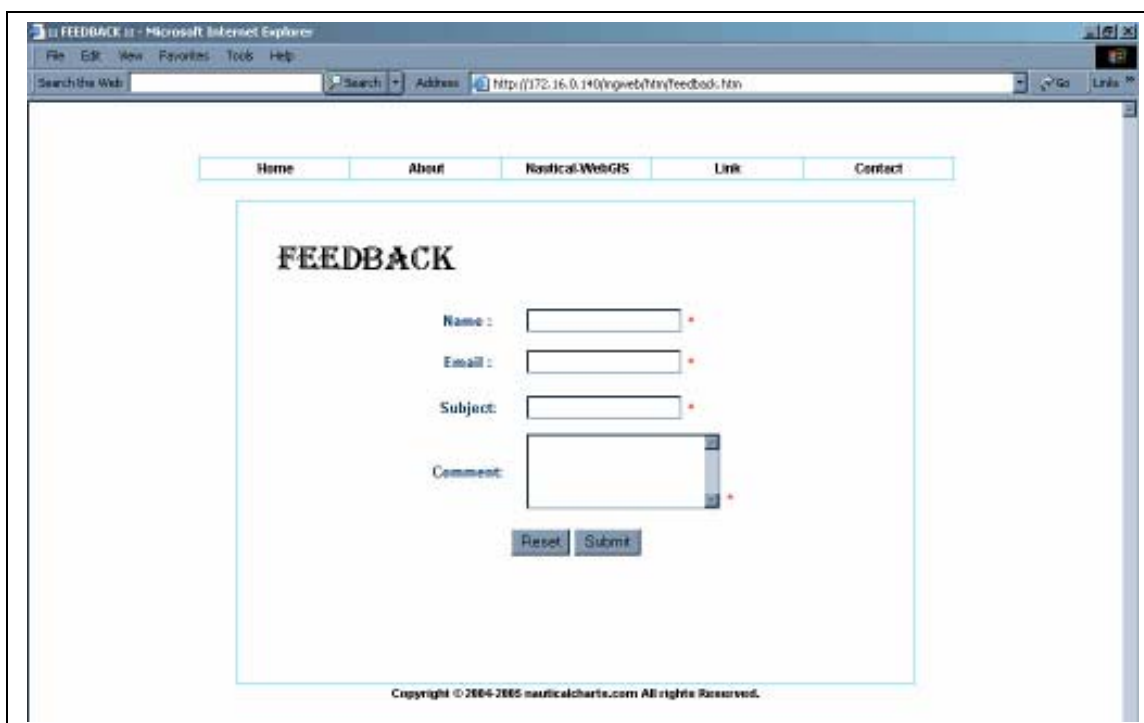




**Figure 7.19:** This Project – Electronic Chart

### 7.2.1.3 Interface of Contact

There are two Web pages are included in the Contact, which are Feedback and also Contact Us. The Feedback is mainly for users to fill in their opinions, comments or suggestions towards Website's content to provide better performance. In these pages, users need to fill in some information likes name, emails, subject of comment as a reference to the Web administrator (Figure 7.20). On the other hand, the Contact Us page list out the information of Web administrator likes address, emails and phone number. Thus, users could contact with the Web administrator easily for further discussions (Figure 7.21).



FEEDBACK

Name :

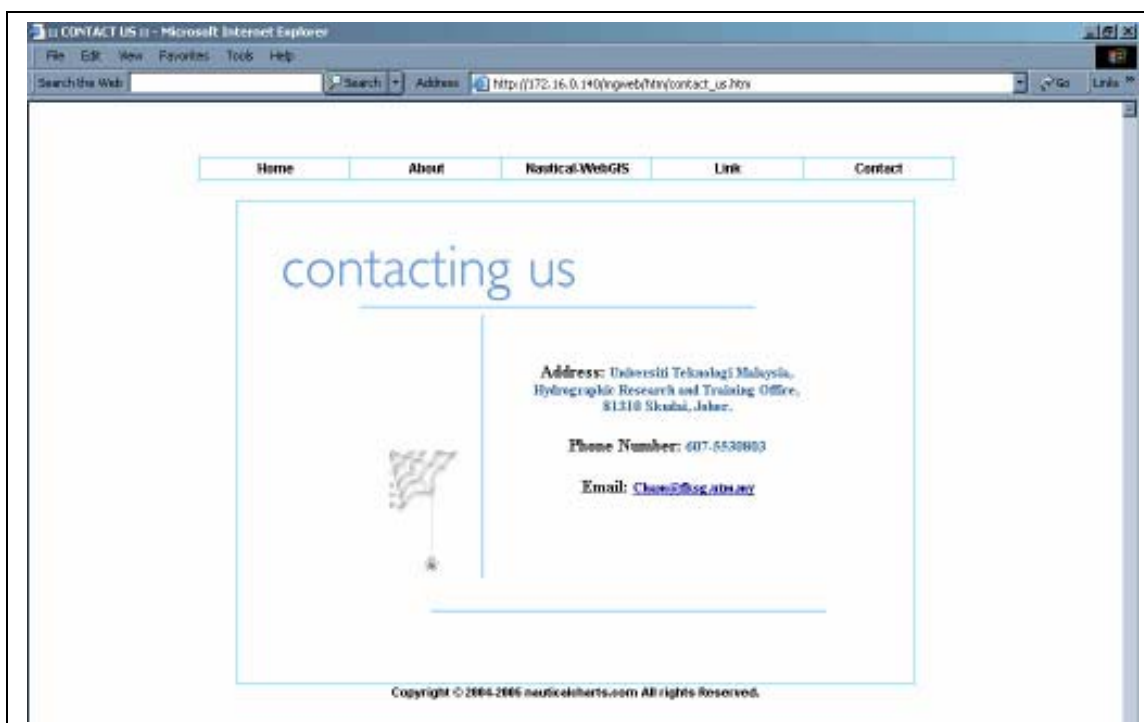
Email :

Subject:

Comment:

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**Figure 7.20:** Contact – Feedback



contacting us

Address: Universiti Teknologi Malaysia,  
Hydrographic Research and Training Office,  
81310 Skudai, Johor.

Phone Number: 607-6538883

Email: [Chuan@hog.atn.au](mailto:Chuan@hog.atn.au)

Copyright © 2004-2006 nauticalcharts.com All rights Reserved.

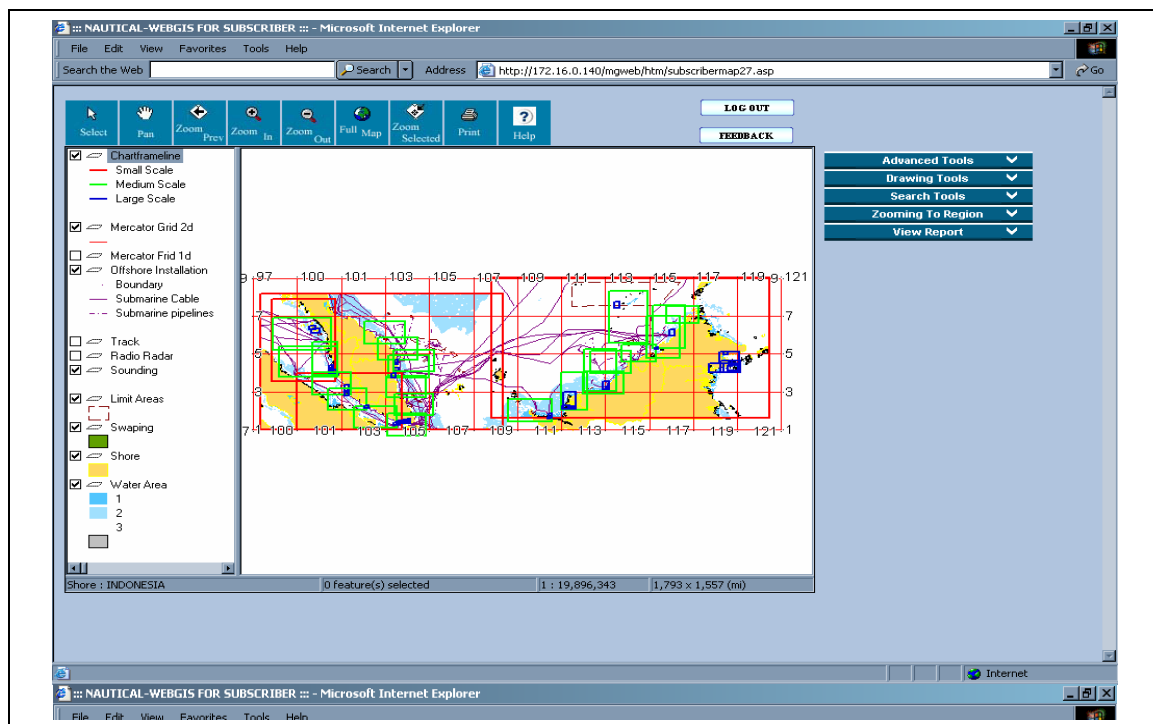
**Figure 7.21:** Contact – Contact Us



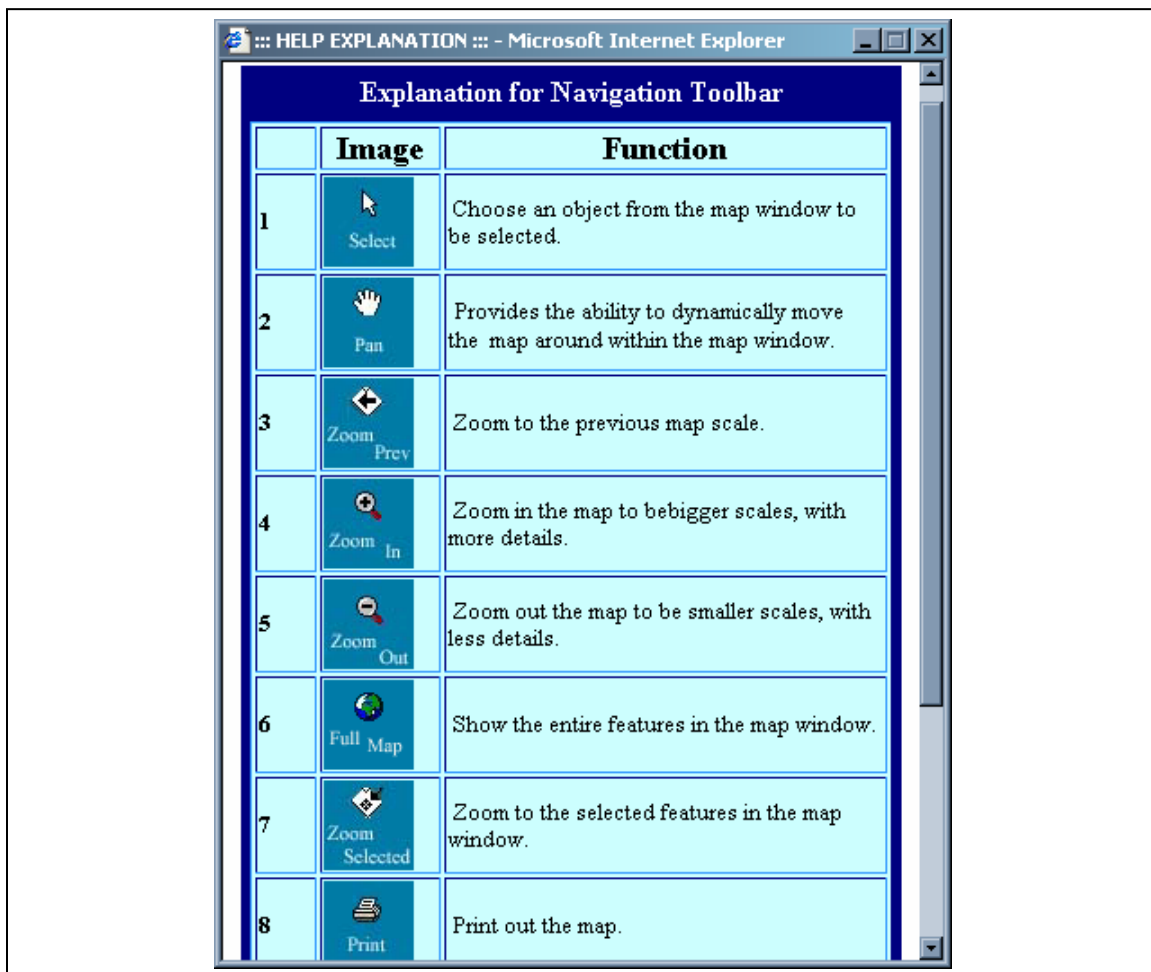
## 7.2.2 Interface of Map Display

In the map display page as shown in Figure 7.22, there have the basic toolbars for user to navigate the map. The uses of the basic toolbar are explained in Figure 7.23. By clicking on the Help button in the basic toolbar, a new window will be displayed with the explanation of button functionalities.

The Map has 8 basic tools above the map window and a list of legend beside the map window. Besides the basic toolbar, there are two buttons called Log out and Feedback. The Log out button is to exit from the map page whereas the Feedback button is to give some comments and opinions towards the map display by filling in a form. At the right hand side of the page, there is a list of query functions for user to access the information that related with the map content. The interface of query functions will be explained in 7.2.3.



**Figure 7.22: Map Display**

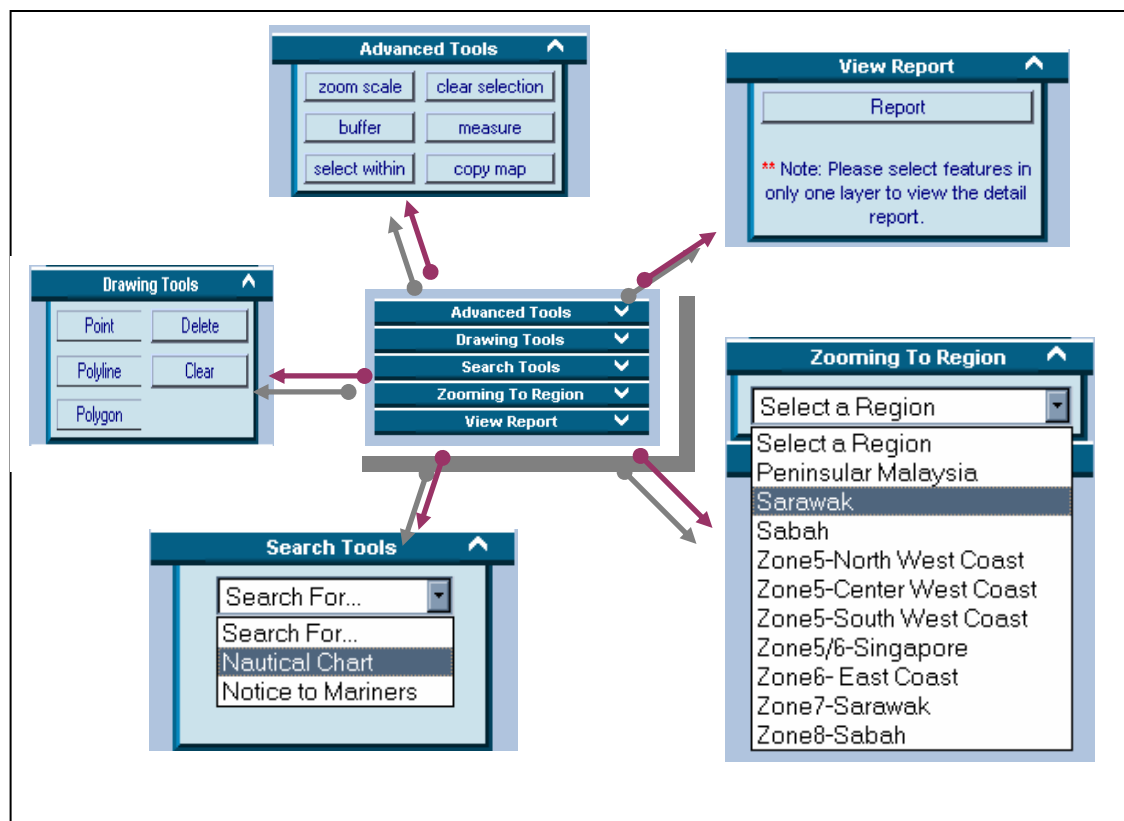


**Figure 7.23:** Help explanation for the basic toolbar

### 7.2.3 Interface of Query Functions

The interface of query functions is in the same page with the Map Display for subscriber. Basically, the query functions can be divided into five sub-sections, which are advance tools, drawing tools, searching tools, zooming to region and the view report.

(Figure 7.24) Each of the sub-sections is being locked in order to save space, by clicking on the small arrow at the corner will enable the list of functions to be showed.



**Figure 7.24:** Sub-sections for the query functions

In the advance tools, there are several tools such as zoom scale, buffer, select within, clear selection, measuring and also copy map. The functionalities of these tools are explained in the Table 7.1.

Table 7.1: Functionalities for advance tools

| No | Tools         | Description   |
|----|---------------|---|
| 1  | Zoom Scale    | To specify the map scale to display through the zoom scale dialog box.                                    |
| 2  | Buffer        | To draw a polygon that locates its boundaries at a certain distance from a point, line, or other polygon. |
| 3  | Select within | To select features those fall within the currently selected   |

|   |                 |  |
|---|-----------------|--|
|   |                 | polygons.  |
| 4 | Clear Selection | To deselect all map features.  |
| 5 | Measuring       | Measure the distance between multiple features in succession. The distance between each segment that measure as well as the cumulative total of all segments measured can be viewed. |
| 6 | Copy Map        | To copy the current map view to the clipboard other location, copy map function is needed.   |

In order to help user in planning and decision-making, the drawing tools are an essential. Here, user able to draw point, polygon or polyline with some styles setting as well. Clear button is mainly to delete all the features that have drawn whereby the Delete button is mainly to delete the selected features that have drawn only.

Searching tools is aim to help user to search information of charts and notices to mariners. For the charts, it can be reached through two searching criteria. Users able to search the chart by filling in the chart code or selecting the state that consists related charts. In addition, there are also two searching criteria to obtain the notices information. Users able to obtain the notices information by filling in the notice code or the charts affected.

In the query function, there is another sub-section called zooming to the region. According to the catalogue of charts, all of the charts have been categorized to 10 regions. The purpose of this function is to help user to view the related region directly, which is actually same view with the catalogue of charts.

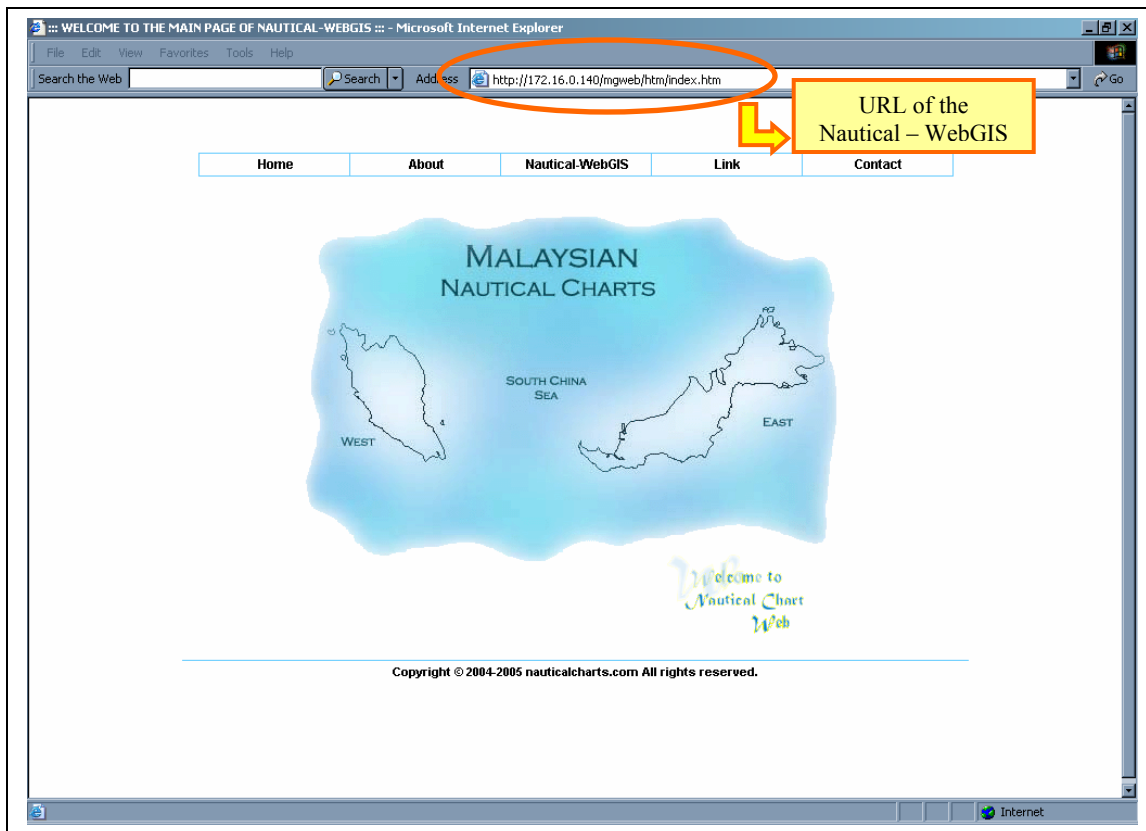
View Report is the last sub-section in the query function. Whenever user selected one or more features in the same layer, user can simply view the detail information of those features by clicking on the View Report button. Furthermore, user able to view the image of that particular chart in the information of charts report.

### **7.3 System Evaluation and Maintenance**

When the interfaces have been customized, all of them need to be tested for upgrading the efficient of Web. Referring to the second objective of this research, it is needed to evaluate and test the Website from four aspects. These four aspects are testing of Web accessible, testing of Web interface, testing of map display and testing of Web function. In testing the application, it may occurred some problems such as certain functions couldn't be run well or users unsatisfied with the interfaces. Therefore, the Web will re-test and re-evaluate if needed.

#### **7.3.1 Testing of Web Accessible**

In testing of Web accessible, a main server computer is a must to launch the application. Then, the Web accessibility will be tested through several client computers in LAN (Local Area Network). In order to enable client computer to access the Web, URL in server computer has to be defined. For this research, the IP address in the server computer will acted as the URL. The URL for client computer to access the Web is <http://172.16.0.140/mgweb/htm/index.htm>. When they access, they will view the main page of the Web as showed in Figure 7.25.



**Figure 7.25:** Main page for the Nautical – WebGIS that could access by client computer through the URL

However, when the number of client computers who accessing the Web are increased, it will affect the speed performance directly. Therefore, three kind of different tests are implemented for multiple users who concurrently accessing online map, querying online map and submit feedback form. From the result, the different speed performance between 5 users is approximately  $0 \leq t \leq 2$  in seconds. The Table 7.2 below shows the changes of speed performance when number of user are gradually increased. As a conclusion of the test, the map server is considered capable in handling the different user requirements.

Table 7.2: Result of testing of Web accessibility

| Number of client | Concurrently Testing on | Average Time (s) |
|------------------|-------------------------|------------------|
| 1                | Accessing online map    | 1.20             |
| 5                | Accessing online map    | 2.10             |
| 10               | Accessing online map    | 3.20             |
| 15               | Accessing online map    | 4.50             |
|                  | Different:              | > 1.10           |
| 1                | Querying online map     | 1.10             |
| 5                | Querying online map     | 2.90             |
| 10               | Querying online map     | 3.40             |
| 15               | Querying online map     | 5.20             |
|                  | Different:              | > 1.03           |
| 1                | Submit feedback form    | 1.4              |
| 5                | Submit feedback form    | 2.2              |
| 10               | Submit feedback form    | 2.9              |
| 15               | Submit feedback form    | 3.5              |
|                  | Different:              | > 0.70           |

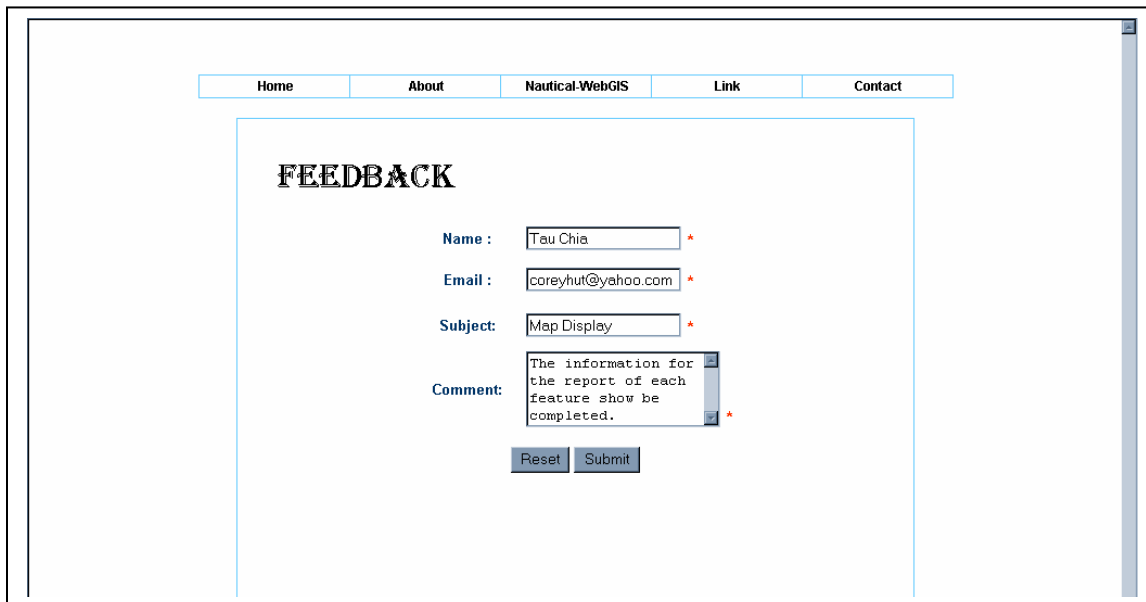
### 7.3.2 Testing of Web Interface

Most of the interfaces are mainly for providing information that related with this research. There are some interface are closely connected with database to receive information that given by users or verify password. Thus, there are three pages are essential to be tested and evaluated for better performance. These three pages are registration, feedback and also the authorization.

### 7.3.2.1 Feedback Page

In the Feedback page, when the users have some opinion or comment, they are welcome to leave a message in the Feedback page. Their contact email must be filled for further discussion if needed. In testing the comments can be received by the Web administrator, some information as Figure 7.26 is filled as an example of comments.

When the user clicks on submit button, comments will be sent to the table comment in subscriber.mdb that kept in server computer. Next, it will proceed to another page for showing the appreciation to users (Figure 7.27). The result of the comments that have been sent successfully through client computer is showed in Figure 7.28.



The screenshot displays a web browser window with a feedback form. At the top, there is a navigation bar with five links: Home, About, Nautical-WebGIS, Link, and Contact. The main content area is titled "FEEDBACK" in a bold, serif font. Below the title, there are four input fields, each with a label and a red asterisk indicating a required field. The "Name" field contains "Tau Chia", the "Email" field contains "coreyhut@yahoo.com", and the "Subject" field contains "Map Display". The "Comment" field is a text area containing the text "The information for the report of each feature show be completed." Below the input fields are two buttons: "Reset" and "Submit".

| Home | About | Nautical-WebGIS | Link | Contact |
|------|-------|-----------------|------|---------|
|------|-------|-----------------|------|---------|

**FEEDBACK**

Name :  \*

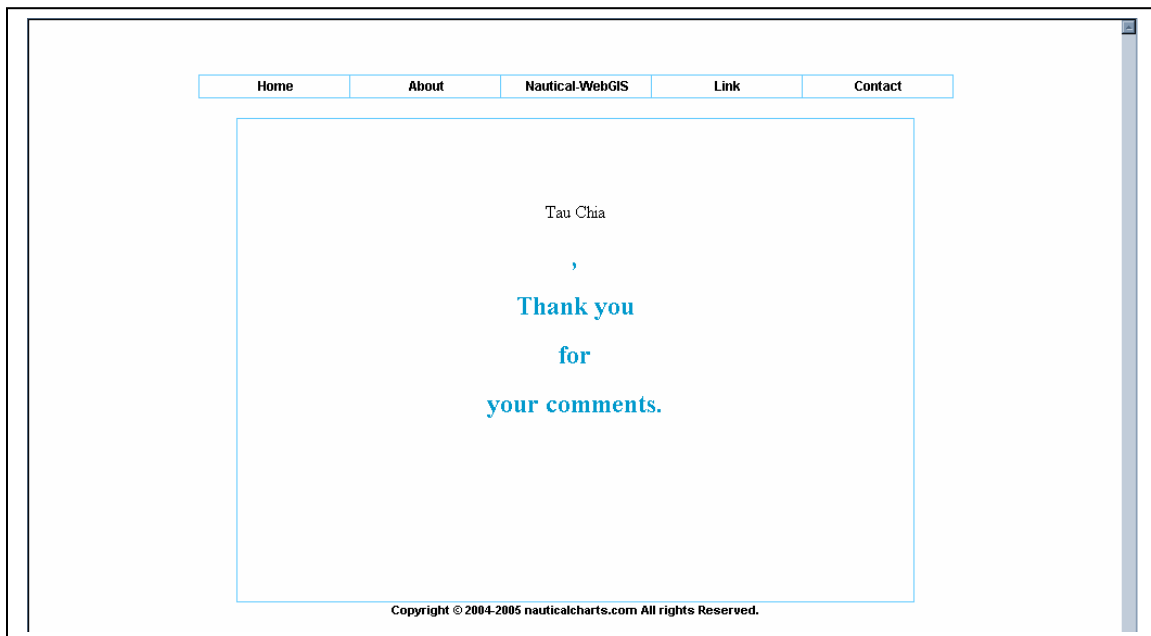
Email :  \*

Subject:  \*

Comment:  \*

**Figure 7.26:** Comments filled by user in Feedback Page





**Figure 7.27:** Page that showing the feedback has been sent successfully

The screenshot shows a table titled "Comments : Table" with the following data:

| ID           | Name     | Email                | Subject     | Comments  |
|--------------|----------|----------------------|-------------|---|
| 1            | Cham     | alicephang@yahoo.com | About       | more pictures are needed.   |
| 23           | Tau Chia | coreyhut@yahoo.com   | Map Display | The information for the report of each feature show be completed. |
| (AutoNumber) |          |                      |             |   |

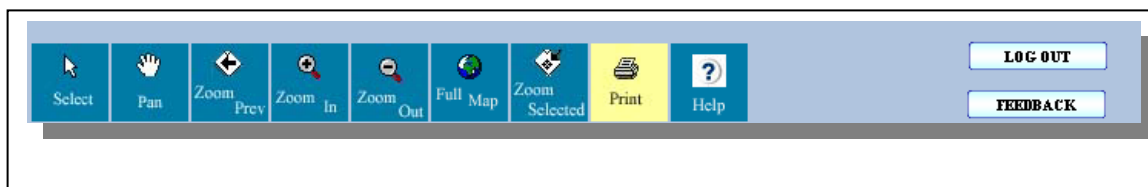
A yellow arrow points from the table to a yellow box labeled "Result of Comments".

**Figure 7.28:**Result of the feedback received by user that kept in table comment

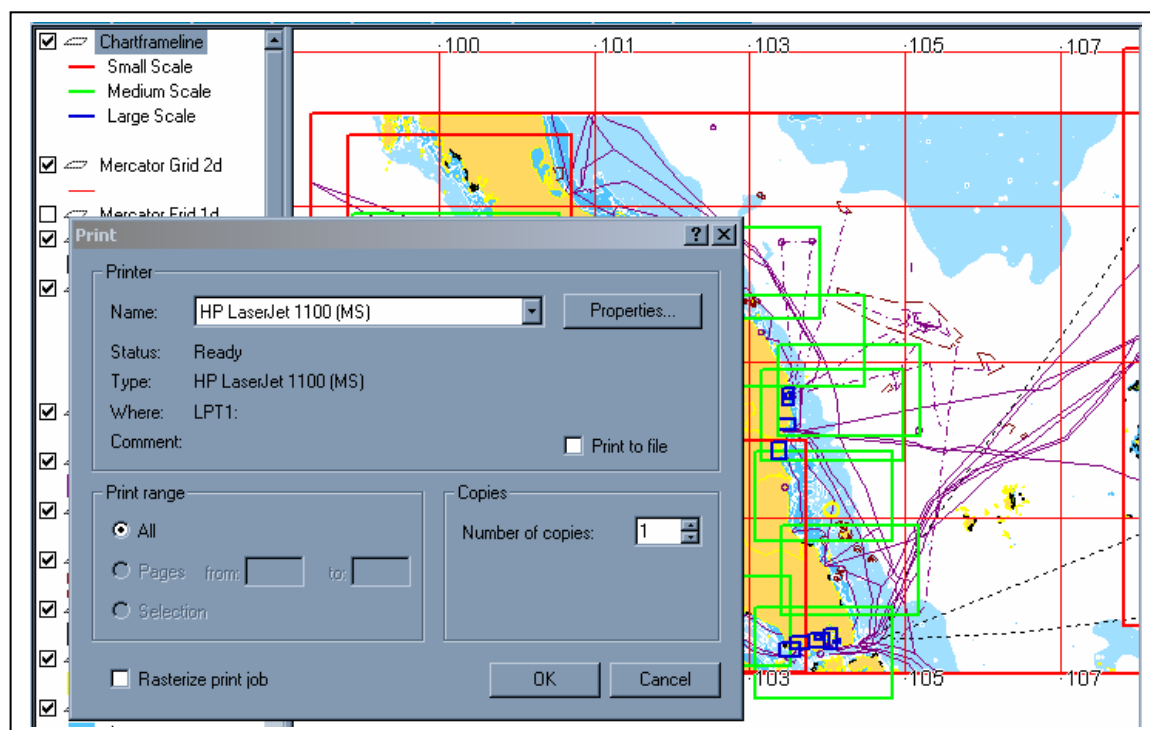
### 7.3.3 Testing of Map Display

There are some basic tools for the map display to help user navigate the map easily. All of the tools can be functioned well. As a test for the tools, Print button was selected. When the button was highlighted, the colour would be changed from blue to

yellow as shown in Figure 7.29. After selected the button, a pop up dialog box will show up for the configuration of printing. In the dialog box, user can define the print area, layout, number of copies and others (Figure 7.30). The print result will show the current view of the map window with legend and scale.



**Figure 7.29:** Basic toolbar in Map Display with Print button highlighted



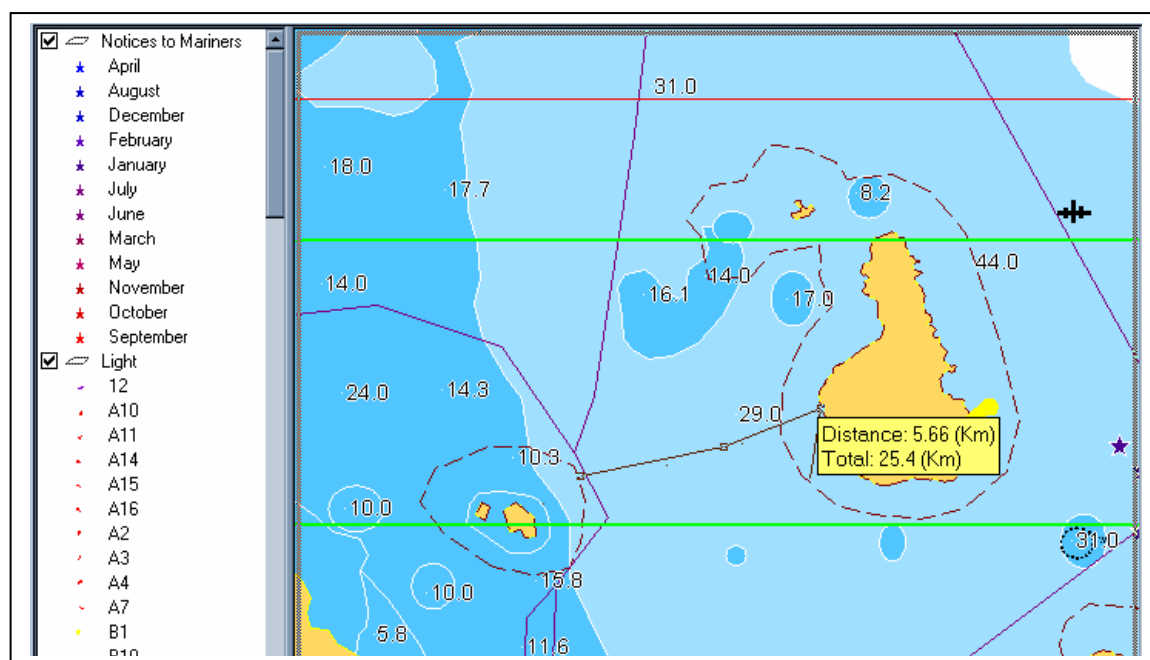
**Figure 7.30:** Print Dialog box for configuration

#### 7.3.4 Testing of Query Functions

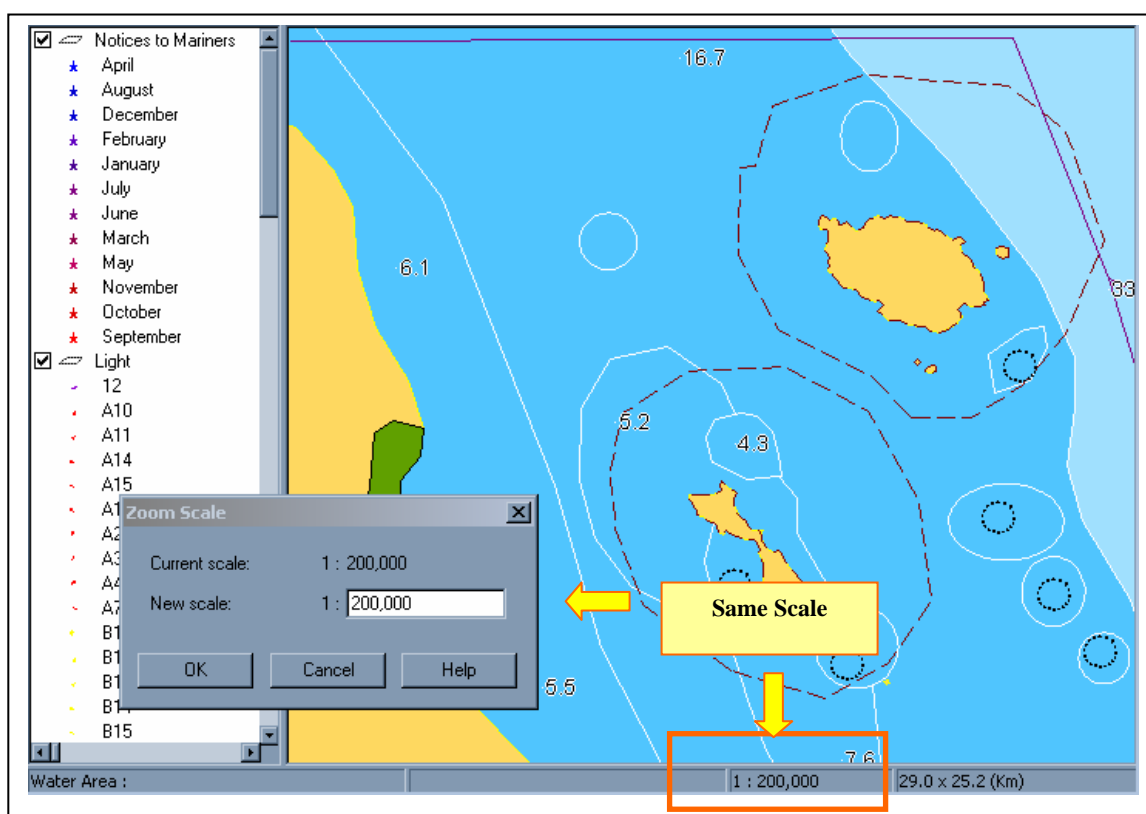
Query functions are considered as one of the important part in this research. It acts as an inter-connected component with the features in the map window for different purposes. And, there are many functions need to be tested, as there are several sub-sections in it.

For the advance tools, some of the functions like Measuring, Zoom Scale, Select Within and Buffering will be tested. As a Measuring example in Figure 7.31, user will obtain the distance between Pulau Tioman and the Marine Park nearby Pulau Seri Buat in kilometer unit. Another example shown in Figure 7.32 is the result of Zoom Scale. When user clicks on the Zoom Scale button, a dialog box will pop up to define to scale. Then, the map window will zoom to the scale that defined by user immediately.

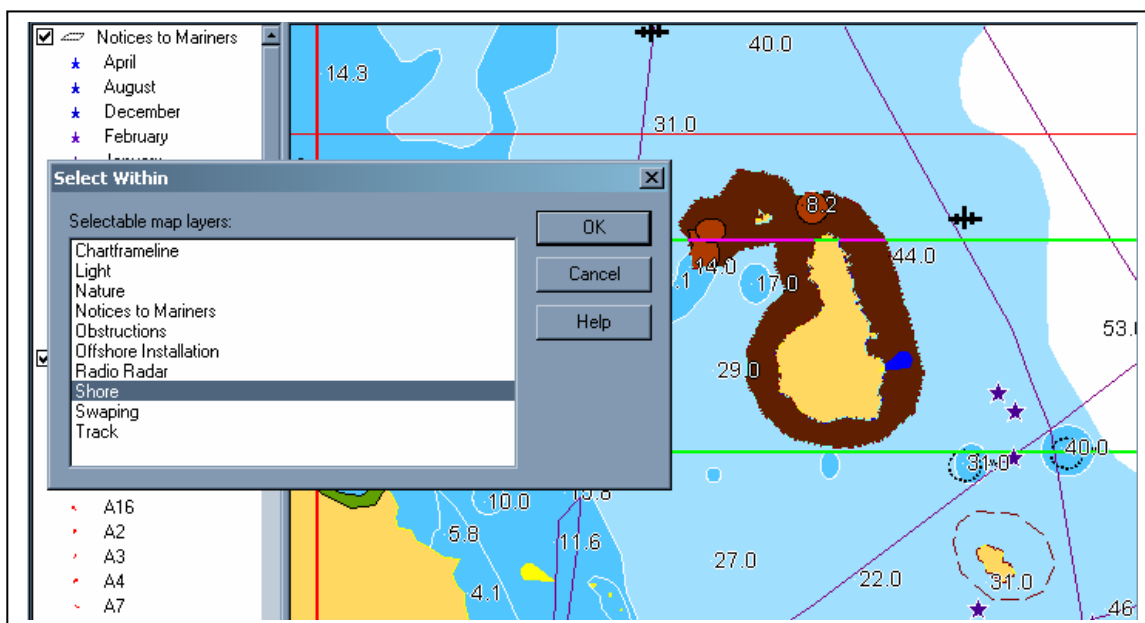
For the testing on Select Within, the marine park around Pulau Tioman was selected initially, when the select within button was clicked, a dialog box will guide user to choose features within the selected area (Figure 7.33). The result of Select Within is shown in Figure 7.34 with Shore layer within the Marine Park selected. Another function in advance tools to be tested is Buffer. A wreck was selected initially, then the Buffer button will guide to a dialog box for configuration (Figure 7.35). Here, a buffer offshore distance 10KM was defined with yellow colour. And, the result of the Buffer is shown in Figure 7.36.



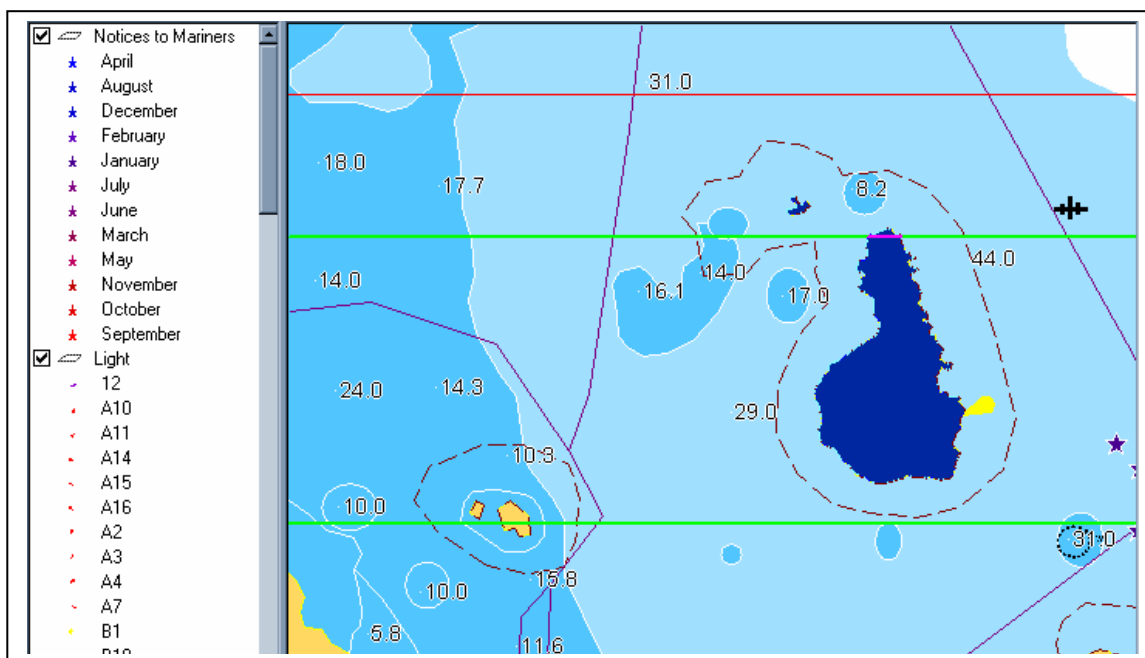
**Figure 7.31:** Result of Measuring between Pulau Tioman and the Marine Park nearby Pulau Seri Buat



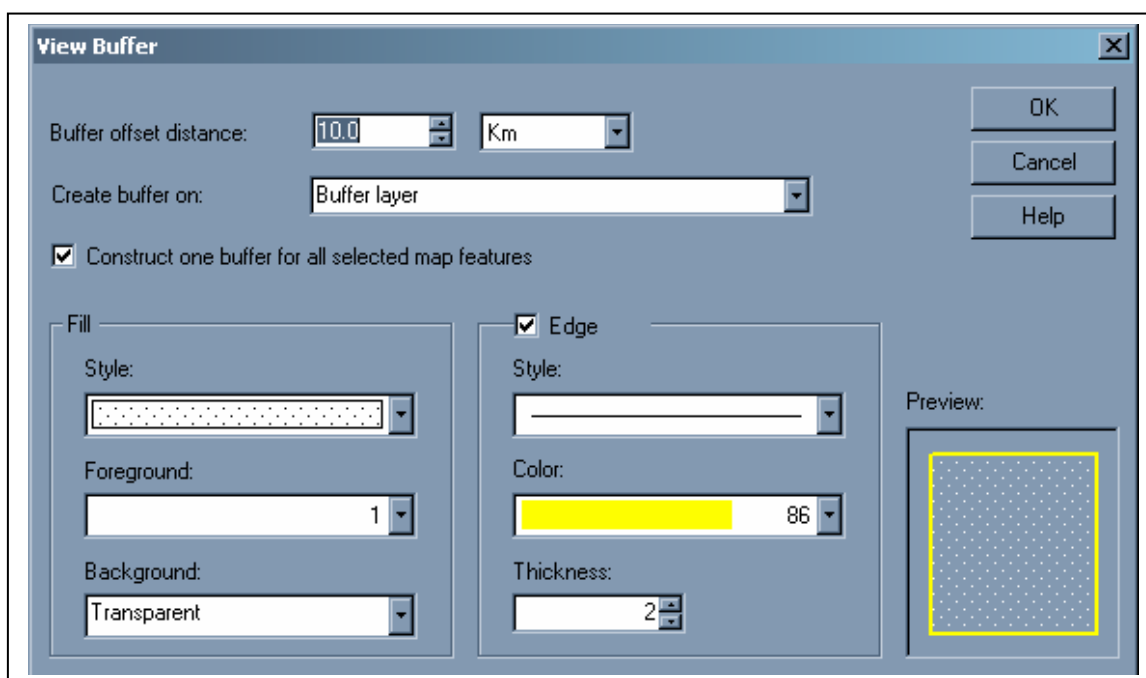
**Figure 7.32:** Result of Zoom scale of 1:200,000



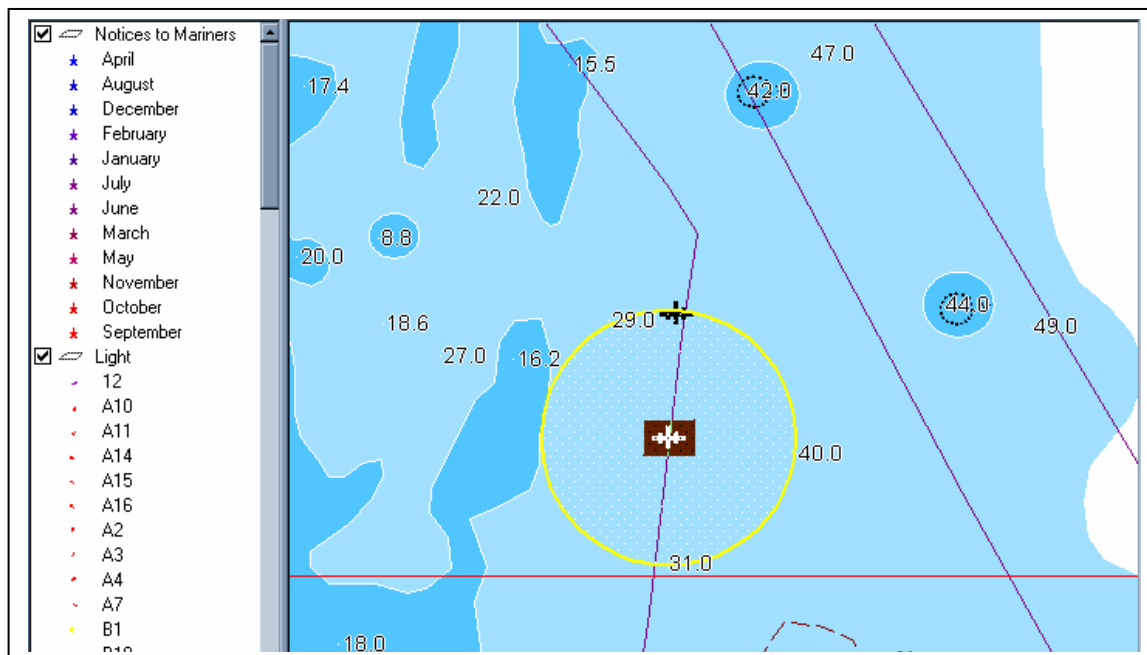
**Figure 7.33:** Dialog box of Select Within to choose layer



**Figure 7.34:** Result of Select Within – Shore layer within the Marine Park selected

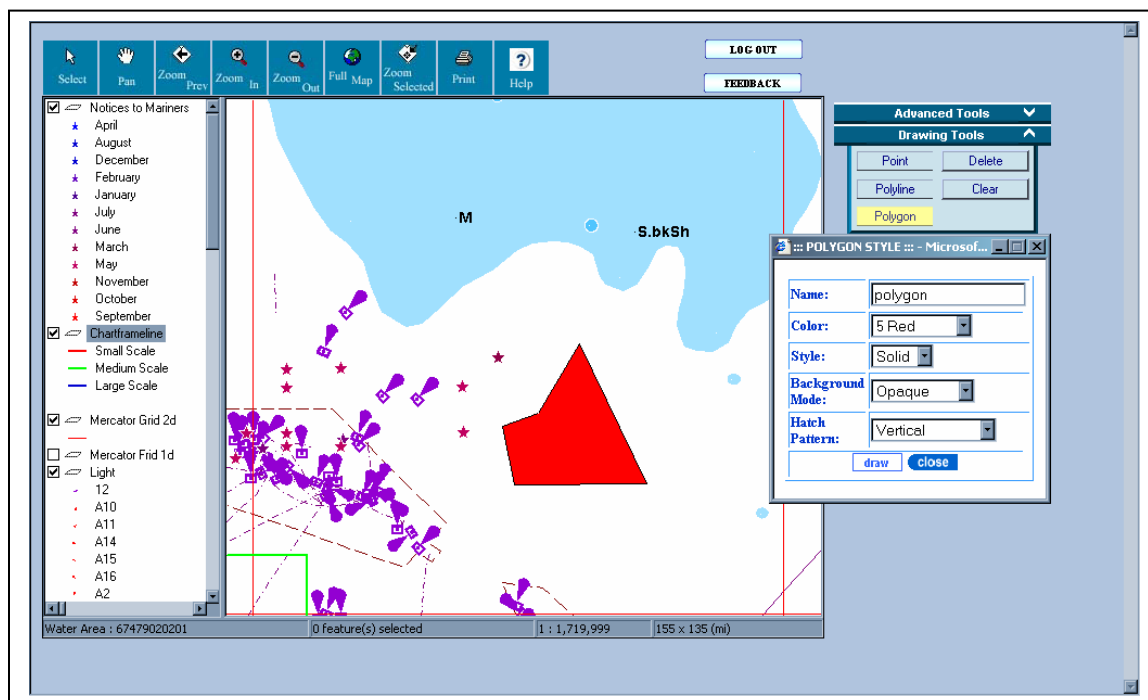


**Figure 7.35:** Buffer Dialog box for configuration



**Figure 7.36:** Result of 10km Buffer for a wreck

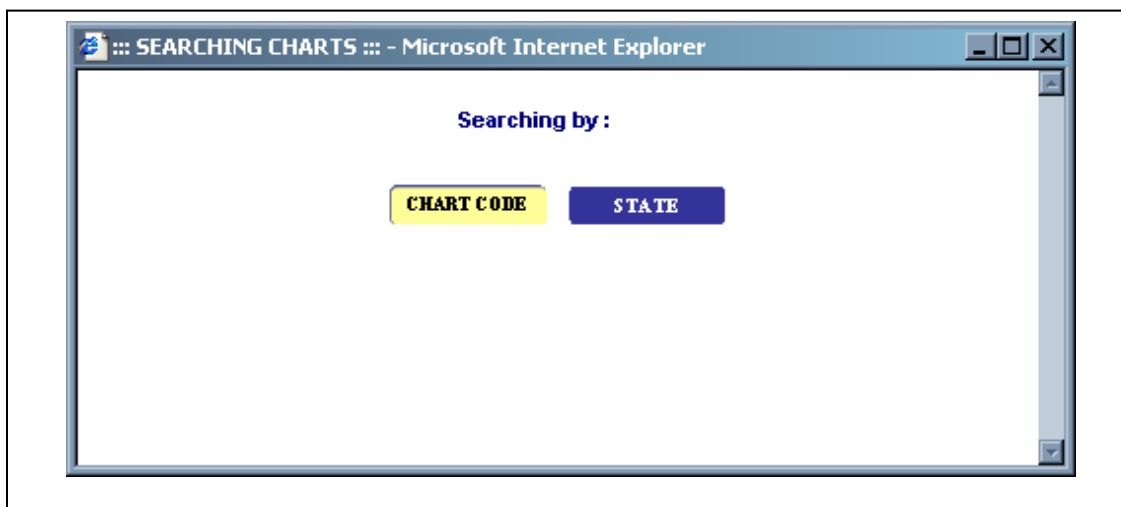
In order to test on the drawing tools can be run smoothly, a polygon was drawn. When the Polygon button was highlighted, the colour will be changed from blue to yellow, after clicking the button, a pop up dialog box will show up for the style of drawing. In the dialog box, user can create a name for that polygon, define the colour, background mode and the hatch pattern. During the test, red colour, and solid style was defined. Thus, the style of drawing result will be exactly same with user defined.(Figure 7.37)



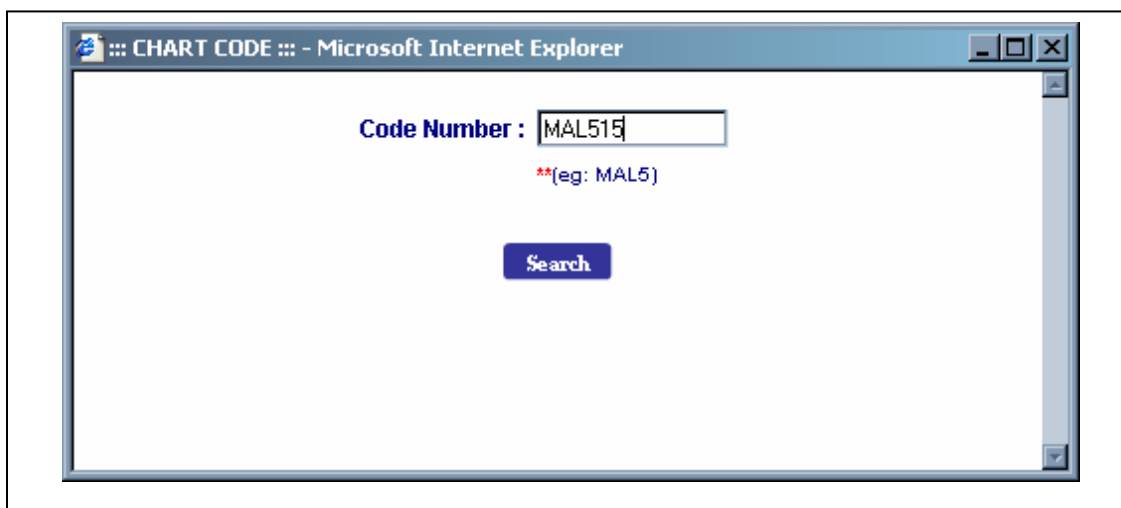
**Figure 7.37:** Result of drawing a polygon in red

As for the Searching tool, a test towards Nautical Charts was implemented. When the Nautical Charts was selected, a dialog window will occur for choosing within searching by Chart Code or State as shown in Figure 7.38. When the Chart Code was clicked on, the current dialog window will turn to Chart Code Search page (Figure 7.39). Here, MAL515 is the chart to be searched. The result will be viewed in the same dialog

window. In the information of the result, there is a Zoom icon to zoom into MAL515 in the map window as shown in Figure 7.40.

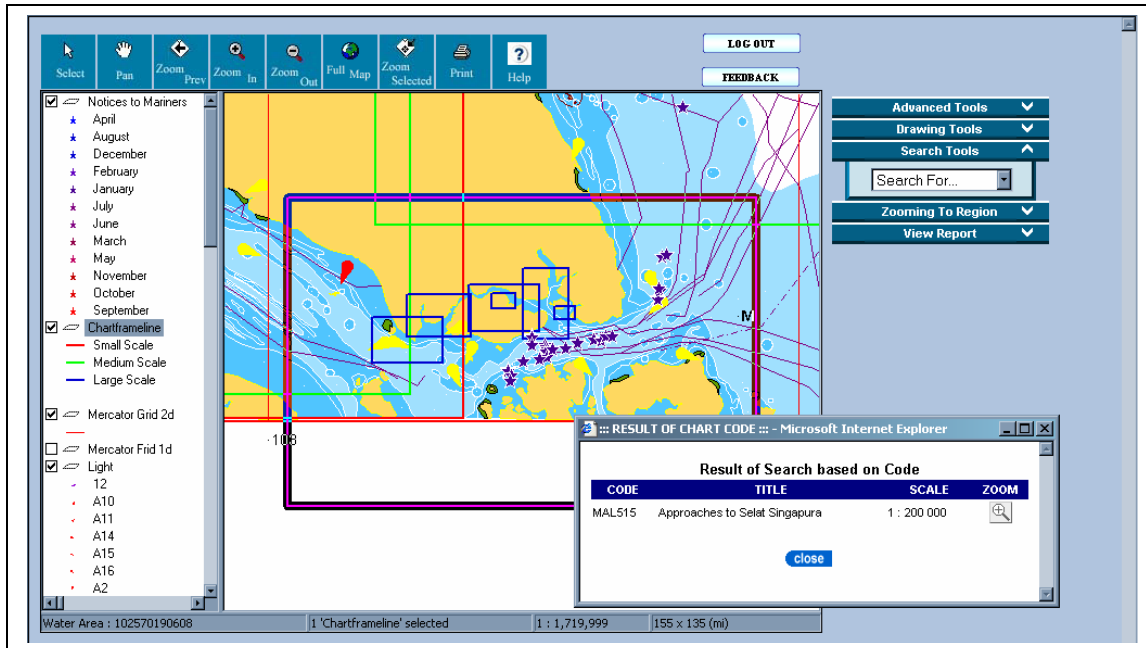


**Figure 7.38:** Dialog window to choose searching criteria



**Figure 7.39:** Dialog window to search chart by code – MAL515

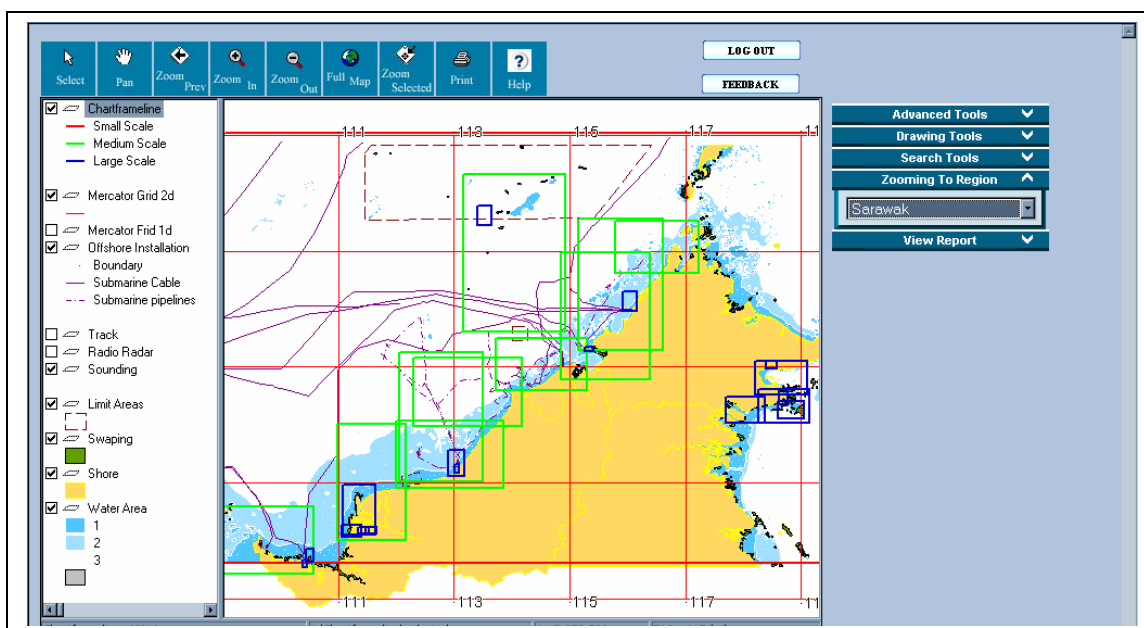




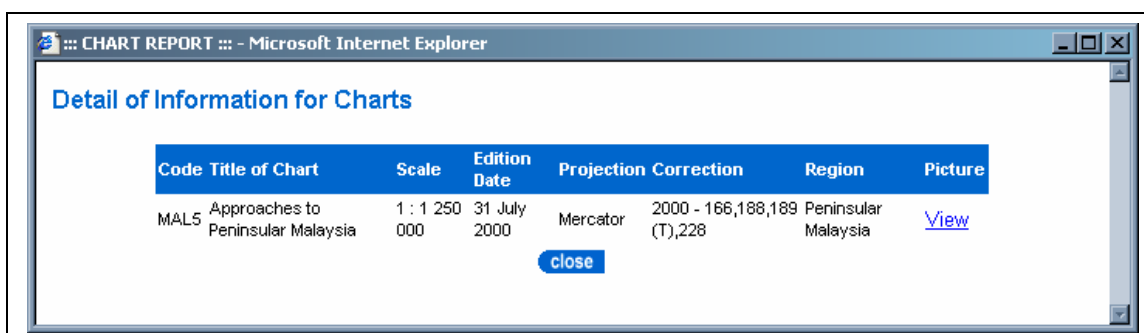
**Figure 7.40:** Result of search shows in a dialog window and zoom into MAL 515 in map window

In testing the Zooming to Region, Zone Sarawak is selected. When the Zone Sarawak selected, the view in the Map Window will directly zoom to Zone Sarawak as shown in Figure 7.41.

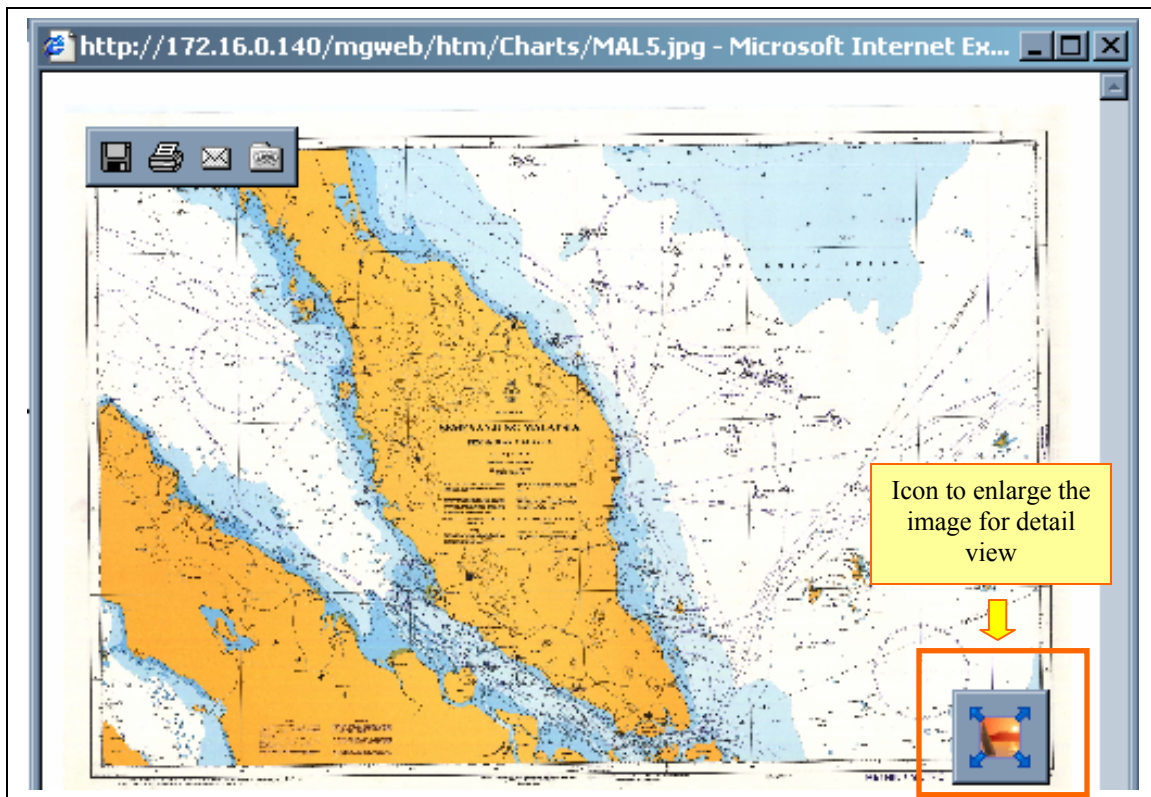
The last sub-section in query functions to be tested is View Report. Here, a chart named MAL5 is selected in the map window. Then, click on the report button to view the detail of information about MAL5. In seconds, a dialog window will appear with the information of MAL5 together with a Picture column (Figure 7.42). By clicking on the View in the Picture column, a new dialog window will show the scanned image of MAL5. There is an icon in the corner for user to enlarge the image for a better view (Figure 7.43).



**Figure 7.41:** Result of Zooming to Region – Zone Sarawak in small scale



**Figure 7.42:** Report of MAL5



**Figure 7.43:** Image of MAL5

## 7.4 Conclusion

Basically, the result and the evaluation of this research are discussed in this chapter. Each result of the interface that content in this research has been shown and explained regarding to its functionalities. The interfaces can be separated to dynamic and static page. Most of the dynamic pages such as feedback page, registration page and subscriber log in page are closely link with a database for processing certain information. Furthermore, the functions that included in Map display page also discussed in detail.

The evaluation of this research was tested through four aspects. There are Web accessible, testing of Web interface, testing of map display and testing of Web function. The results of testing are shown as well and all of these four aspects can be run smoothly through LAN.

## **CHAPTER 8**

### **CONCLUSION AND RECOMMENDATION**

#### **8.1 Background**

Basically, the obtained result from both phases in this study has achieved the objectives of this research, which are (i) To develop a digital nautical chart in vector form for small boats and leisure crafts in Malaysia using CARIS GIS 4.4a; (ii) To advance the digital nautical chart into Web platform using Autodesk MapGuide 6.03. Thus, it has brought up a variety of benefits to the end users.

Here, the conclusion and the recommendation of this study will be discussed in detail. For the conclusion, there is a short and compact summary of the whole research that regarding to both phases of the system creation. Other than that, some of the recommendation for future development of this research also will be discussed.

## 8.2 Summary of the Research – Phase I

The processes of developing the vector nautical chart for MAL 5622 can be divided into four steps, which are data digitisation, building topology, and development of database and implementation of analyses.

Basically, the data digitisation can be done through CARIS SAMI in CARIS GIS 4.4a. In this study, researchers chose to digitise using on-screen digitisation method. Actually, CARIS SAMI also prepared an application for converting data raster into vector in a semi-automatic way. This application is mainly for geometry data in the form of polylines, such as contour lines, coastlines and roads. However, researches might need to spend more time in editing data if using the application to make sure the vectorised polylines are truly link with other features. To solve the problem, all of the features were digitised on-screen and divided to different themes.

Topology is aim to solve all of the error that caused by improper digitisation so that it can form polygon from polylines and build up network between features. The two main errors to be solved while building topology are undershoot and overshoot. Polygons with topology enable user to identify each polygon or area based on its polygon keys that kept in CARIS Information Manager. Besides, polygons also can be coloured filling after building topology.

Microsoft Excel is the software to help researchers in building a database for e attribute data in this study. It saved in to \*.dbf format as dBASE IV file. The field name of primary key to link the attribute data with the spatial data is called KEY. It aims to help user to implement the query in CARIS Database Manager or CARIS Information Manager.

From the obtained analytical result in this study, calculating distance provided by menu *Query > Distance Between 2 Points* from CARIS Editor and CARIS Information

Manager gave the distance in nautical mile relayed on map scale. Therefore, users will obtain inaccurate value from there and they need to calculate the actual value manually using given geodetic value.

Other than that, network analyses and zone analyses also executed at the end of the research. Some of the vital elements are the connection for CARIS DDE (CARIS Dynamic Data Exchange) and menu *load network* should be active before implementing network analyses. Based on the result of this study, an analytical study for navigational reference can be done.

### **8.3 Summary of the Research – Phase II**

In expanding this study, the data that added are the series of Malaysian nautical charts and the latest 2004/2005 Notices to Mariners for MAL 5 and MAL 6. There are about 65 sheets of charts included, whereby MAL 5 and MAL6 in vector format and other are in raster format. The main softwares that used are Autodesk MapGuide 63 and ArcInfo Workstation. Additionally, Javascript and ASP also used for the Web customisation.

Data preparation and database design have been done in the first phase of methodology. The certain data have been collected from both RMN and Marine Departments. Then, the datasets are projected in RSO. For the database design, the conceptual design has proved the relationship between the Malaysian charts and notices are one to many, where by a Malaysia Chart can have none of the notices or it can be many notices. In contrast, notices would minimum affected a Malaysia Chart or it can be affected a series of Malaysia charts.

The second step of the methodology is system configuration and Web building. There are three servers installed for this research, which are IIS Web server, Autodesk MapGuide application server and MapAgent as a medium between Web server and application server. The URL for this research is set in LAN during system configuration to enable multiple users to view the application. Besides, the datasets are converted into SDF format and loaded into Autodesk MapGuide Author. For the database that links with spatial data is configured in ODBC data sources and drivers to enable it to be viewed through the LAN.

The Web building has separately developed the content of the Web application into dynamic pages and static pages. The dynamic pages can be divided into two sections. There are development of dynamic map and development of interactive query. The Dynamic map and the interactive query are both in the same page. The map to be embedded are in dynamic map page with some related basic navigate tools. However, the interactive query page is developed using programming languages, such as Jscript and ASP for advance navigate and analyse tools. For the static pages, there are mainly for providing some information to users. Some of the information that consisted in static pages is symbol explanation, nautical charts and Web-based GIS.

The result of the research has been discussed regarding to its functionalities. And, most of the dynamic pages such as feedback page is closely link with a database for processing certain information. The results are being evaluated and tested through LAN by some users to test on its accessibility, Web interface, map display and also Web function. The testing result of Web accessible is considered well because the different speed performance between 5 users is approximately  $0 \leq t \leq 2$  in seconds only. For other test is being done in details and all of them can be run smoothly in LAN.



Along with the progress of this research, there are some difficulties that influence the final result. These difficulties have led to the recommendation and suggestion for further studies that related with this research.

## **8.4 Recommendation**

In order to enhance the result of this research, there are some recommendations have been suggested for future development. Some are the recommendations are supporting ENC S-57 format, importing geoprocessing functionalities, self-monitoring system, real time tide level, providing all charts in vector and others.

### **8.4.1 Supporting ENC S-57 Format**

In order to produce high quality digital nautical chart, it should able to support ENC S-57 data. Through this way, the operation of charts not only can be done in CARIS but also in other navigational software. As a suggestion, CARIS HOM (Hydrographic Object Manager) needs to add into CARIS GIS 4.4a package. CARIS HOM enable conversion format for CARIS file, which is *\*.des* and other supporting files into a smaller format file named *\*.000* and fail *\*.hob*.

### **8.4.2 Importing Geoprocessing Functionalities**

Based on GIS concepts, there are a variety of functionalities can be implemented to assist users in solving their certain problems. Geoprocessing is considered one of the useful analyses tool that dealing with spatial data. It is a way to create new data based on layers in map window. In most cases, users will alter the geometric properties of the features in a dataset while controlling some aspects of how its attribute data is handled.

The functions of geoprocessing can be divided to three types with different purposes, which are reduce the extent of the layer (e.g., intersect, clip), combine features in same layers (e.g., dissolve) and combine features in different layers (e.g., merge, union). The importing of geoprocessing functionalities into result should be considered to improve the analyses of data.

### **8.4.3 Self-monitoring System**

In order to enhance the studies in the aspect of updating marine data, it is recommends to implement the self-monitoring systems to monitor the operation in real-time. The monitoring system shows the direction of vessels in reality whenever they are within the boundaries of Malaysia. The vessel can be presented in different type of colour or symbol to differentiate the vessel types.

The self-monitoring system provides an easiest and fastest way for updating data on time. In additional, users or navigators are able to do a simulation to plan the route of

navigation. However, to launch this system, GPS (Global Positioning System) needs to be installed in the servers as well as the vessel for tracking the location of vessel into the Nautical – WebGIS in reality.

#### **8.4.4 Real Time Tide Level**

As we know that the tide level is an important issue for mariners because it will affect vessel draft indirectly. The vessel draft will determine whether or not the vessel is safe in approaching port channel. As an example, a vessel with heavier weight, it will need to approach the port channel when the tide level is higher than normal.

Therefore, it is strongly recommended to further this studies with an add in component, which allow user to input the under keel clearance and vessel draft for that particular area for showing the real time tide level to assist mariners in decision making. The result of can be shown in graph or animation and it will be updated in real time after a period of time (user define).

#### **8.4.5 Others Recommendation**

Other than those recommendations that have been discussed in the above, there are still some minor suggestions to improve the research. These suggestions are listed as below:

- (i) Improving the visualization of digital nautical chart through CARIS 3D Viewer to present data in three dimensions.
- (ii) Animated the user interface of the Web to provide information to users in an effective way.
- (iii) Improving the presentation of the spatial features in map window to be more attractive
- (iv) Adding more contents into the Web, such as latest news that regarding to Malaysia, charts, notices, hydrography and others.

## **8.5 Conclusion**

In order to improve the safety navigation for international water area, varieties of efforts have done by different parties in integrating rules and standard related with navigational aspects. Normally, a boat or vessel involved in navigation must bring along paper charts as navigational aid. But, additional element for navigation also need for boats and vessels based on the specification of SOLAS.

In this study, small boats and leisure crafts that discussed are not SOLAS vessel that need to bring along ECDIS during navigation. Therefore, navigators for small boats and leisure crafts mostly relay on paper charts or electronic chart for planning and analyses. In another words, they are free from SOLAS rules during navigation for bringing specific navigational aid tools except paper charts.

Navigators for small boats and leisure crafts can use any navigational aid during their navigation. In order to improve their safety of navigation, it is better to use vector digital nautical chart as produced in this research. The result of the first phase in this study can help user in updating data from time to time and it can be kept longer than paper charts.

In the second phase of this study, the integration of Web-Based GIS into nautical charting has proved the GIS functionalities can really help users to reach or access needed chart information in an interactive way without the need of GIS software. Moreover, the charts information together with the Notice to Mariners is able to be managing properly with a systematic Web system particularly in data sharing.

According to the recommendation mentioned above, this research is obviously has the potential to expand in order to explore the new technology to the public.

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|      |  |     |
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## LIST OF NOTATION

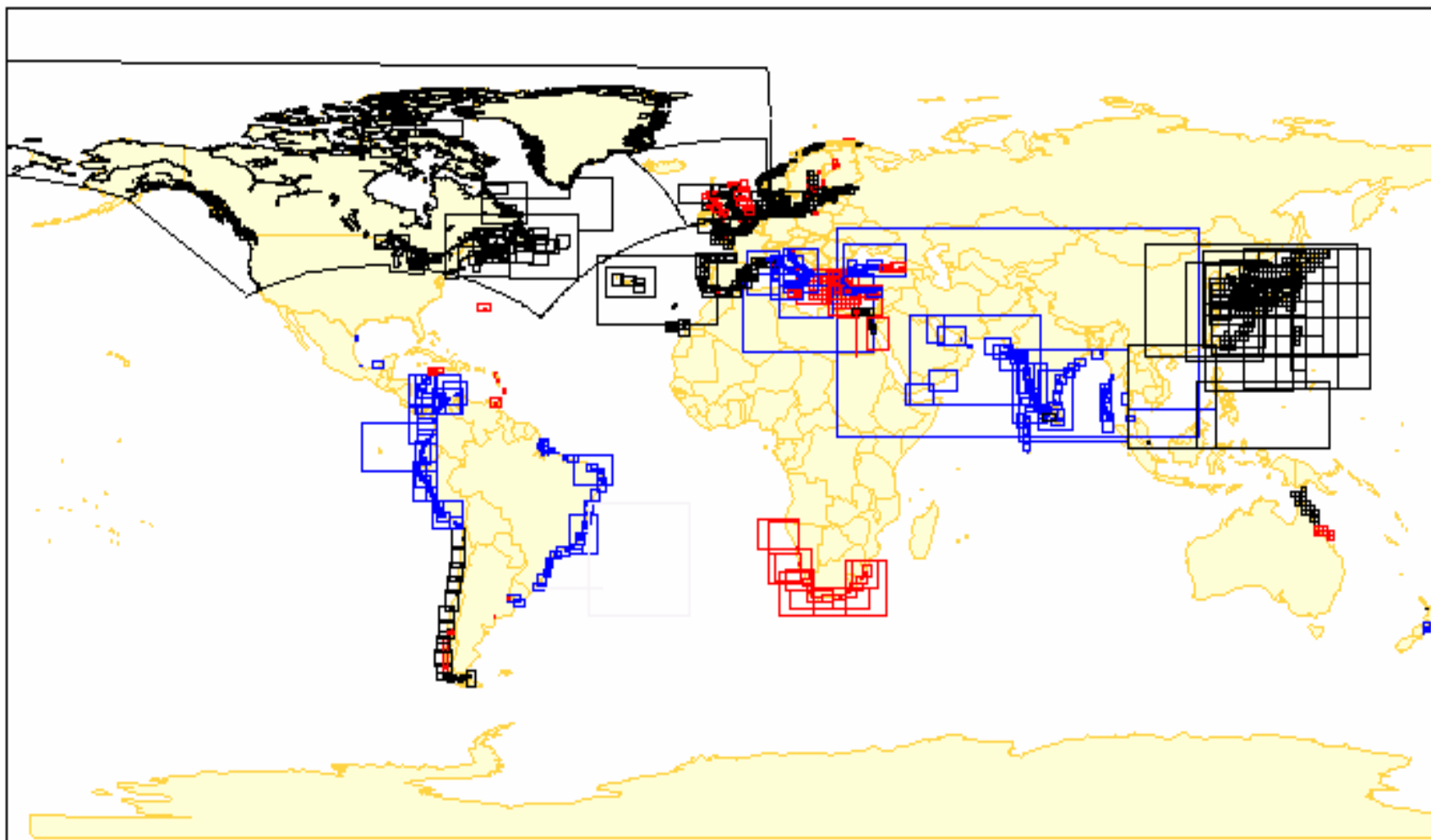
|            |   |  |
|------------|---|--|
| AHS        | - | Australian Hydrographic Service                    |
| AIS        | - | Automatic Identification System                    |
| ARCS       | - | Admiralty Raster Chart System                      |
| API        | - | Application Programming Interface                  |
| ASCII      | - | American Standard Code for Information Interchange |
| ASP        | - | Active Server Page                                 |
| ADOs       | - | ActiveX Data Objects                               |
| CARIS      | - | Computer Aided Resource Information System         |
| CHS        | - | Canadian Hydrographic Service                      |
| CSV        | - | Microsoft Excel Comma Separated Values Files       |
| CGI        | - | Common Gateway Interface                           |
| CPU        | - | Central Processing Unit                            |
| COBRA      | - | Common Object Request Broker Architecture          |
| CAD        | - | Computer Aided Design                              |
| CZM        | - | Coastal Zone Management                            |
| DBMS       | - | Database Management System                         |
| DGIWG      | - | Digital Geographic Information Working Group       |
| DLG        | - | Digital Line Graph                                 |
| DNC        | - | Digital Nautical Chart                             |
| DSN        | - | Data Source Name                                   |
| DWG        | - | Drawing file format                                |
| ENC        | - | Electronic Navigational Chart                      |
| ECDIS      | - | Electronic Chart Display and Information System    |
| ECS        | - | Electronic Chart System                            |
| ER Diagram | - | Entity Relationship Diagram                        |
| FTP        | - | File Transfer Protocol                             |
| GPS        | - | Global Positioning System                          |
| GCP        | - | Ground Control Point                               |

|       |   |   |
|-------|---|---|
| GIS   | - | Geographic Information Systems                      |
| GUI   | - | Graphical User Interface                            |
| HIS   | - | Hydrographic Information System                     |
| HTML  | - | Hypertext Markup Language                           |
| HTTP  | - | Hypertext Transfer Protocol                         |
| HO    | - | Hydrographic Office                                 |
| IALA  | - | International Association of Lighthouse Authorities |
| IEC   | - | International Electrotechnical Commission           |
| IENC  | - | Inland-Waterway Electronic Navigation Chart         |
| IHB   | - | International Hydrographic Bureau                   |
| IHI   | - | Italian Hydrographic Institute                      |
| IHO   | - | International Hydrographic Organisation             |
| IIS   | - | Internet Information Services                       |
| IMO   | - | International Maritime Organisation                 |
| IEC   | - | International Electrotechnical Commission           |
| IP    | - | Internet Protocol                                   |
| ISAPI | - | Internet Server Application Programming Interface   |
| LAN   | - | Local Area Network                                  |
| LES   | - | Land Earth Stations                                 |
| LADA  | - | Langkawi Development Authority                      |
| MWF   | - | Map Windows File                                    |
| NSAPI | - | Netscape Server API                                 |
| NSF   | - | National Science Foundation                         |
| NGDI  | - | National Geospatial Data Infrastructure             |
| ODBC  | - | Data Source Administrator                           |
| PDF   | - | Adobe Portable Document Format                      |
| POP   | - | Points of Presence                                  |
| RMN   | - | Royal Malaysian Navy                                |
| RNS   | - | Raster Navigational Charts                          |
| RSO   | - | Rectified Skew Orthomorphic system (RSO)            |
| RNC   | - | Raster Navigational Chart                           |
| RTCM  | - | Radio Technical Commission for Maritime Services    |
| RCDS  | - | Raster Chart Display System                         |

|         |   |   |
|---------|---|---|
| S-57    | - | Standard 57   |
| SENC    | - | System Electronic Navigational Chart                        |
| SDTS    | - | Spatial Data Transfer Standard                              |
| SOLAS   | - | Safety Of Life At Sea                                       |
| TIFF    | - | Tagged Image File Format                                    |
| TIN     | - | Triangulated Irregular Network                              |
| TLDM    | - | <i>Tentera Laut Diraja Malaysia</i>                         |
| TVP     | - | Topological Vector Profile                                  |
| TCP     | - | Transmission Control Protocol                               |
| UTM     | - | Universal Transverse Mercator                               |
| URL     | - | Uniform Resource Locator                                    |
| UKHO    | - | United Kingdom Hydrographic Office                          |
| US NOAA | - | American National Oceanic and Atmospheric<br>Administration |
| VDR     | - | Voyage Data Recorder  |
| VLCC    | - | Very Large Crude Carrier                                    |
| VPF     | - | Vector Product Format                                       |
| WEND    | - | World-wide Electronic Navigational Chart Database           |
| WWW     | - | World Wide Web  |
| SGML    | - | Standard Generalized Markup Language                        |
| SDF     | - | Spatial Data File   |
| SHP     | - | Shape file format   |

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Study Area of ENC S-57 for Whole World by IHO Till March

## APPENDIX B

### Example of questionnaires for Nautical – WebGIS need assessment

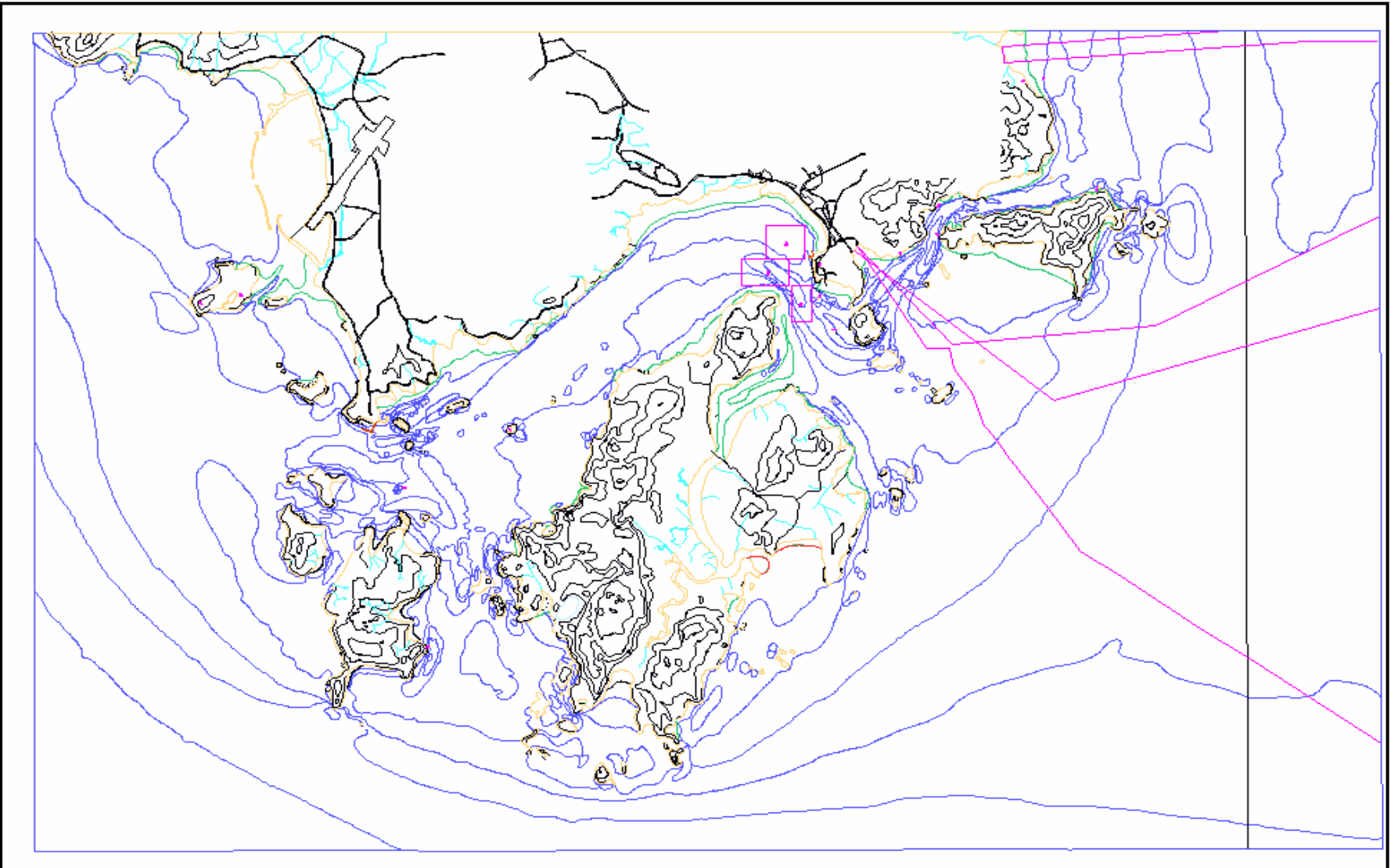
*Please Tick ✓ at the answer that you choose :*

- 1) Have you ever heard of using Web-Based GIS (Geographic Information System) application to manage data?  
☐ Yes ☐ No
- 2) Currently, is there any computer system to manage the Nautical Charts or Notice to Mariners in your office?  
☐ Yes ☐ No
- 3) Is there Internet facility available for your work?  
☐ Yes ☐ No
- 4) Do you have trouble to access the needed Nautical Charts or Notice to Mariners in other states (i.e. is there any difficulties in obtaining the required Nautical Charts or Notice to Mariners)?  
☐ Yes ☐ No
- 5) What kind of information in a Nautical Chart do you usually look into?  
☐ Water Area  
☐ Beacon/ Light House  
☐ Shore/ Nature  
☐ Swamping Area  
☐ Sounding  
☐ Radio/ Radar  
☐ Coordinates  
☐ Offshore Installation  
☐ Others (i.e.: \_\_\_\_\_)
- 6) Based on question 5, according to your opinion what is the most important information? Please list in order of importance starting from 1 onwards.  
☐ Water Area  
☐ Beacon/ Light House  
☐ Shore/ Nature  
☐ Swamping Area  
☐ Sounding  
☐ Radio/ Radar  
☐ Coordinates  
☐ Offshore Installation  
☐ Others (i.e.: \_\_\_\_\_)

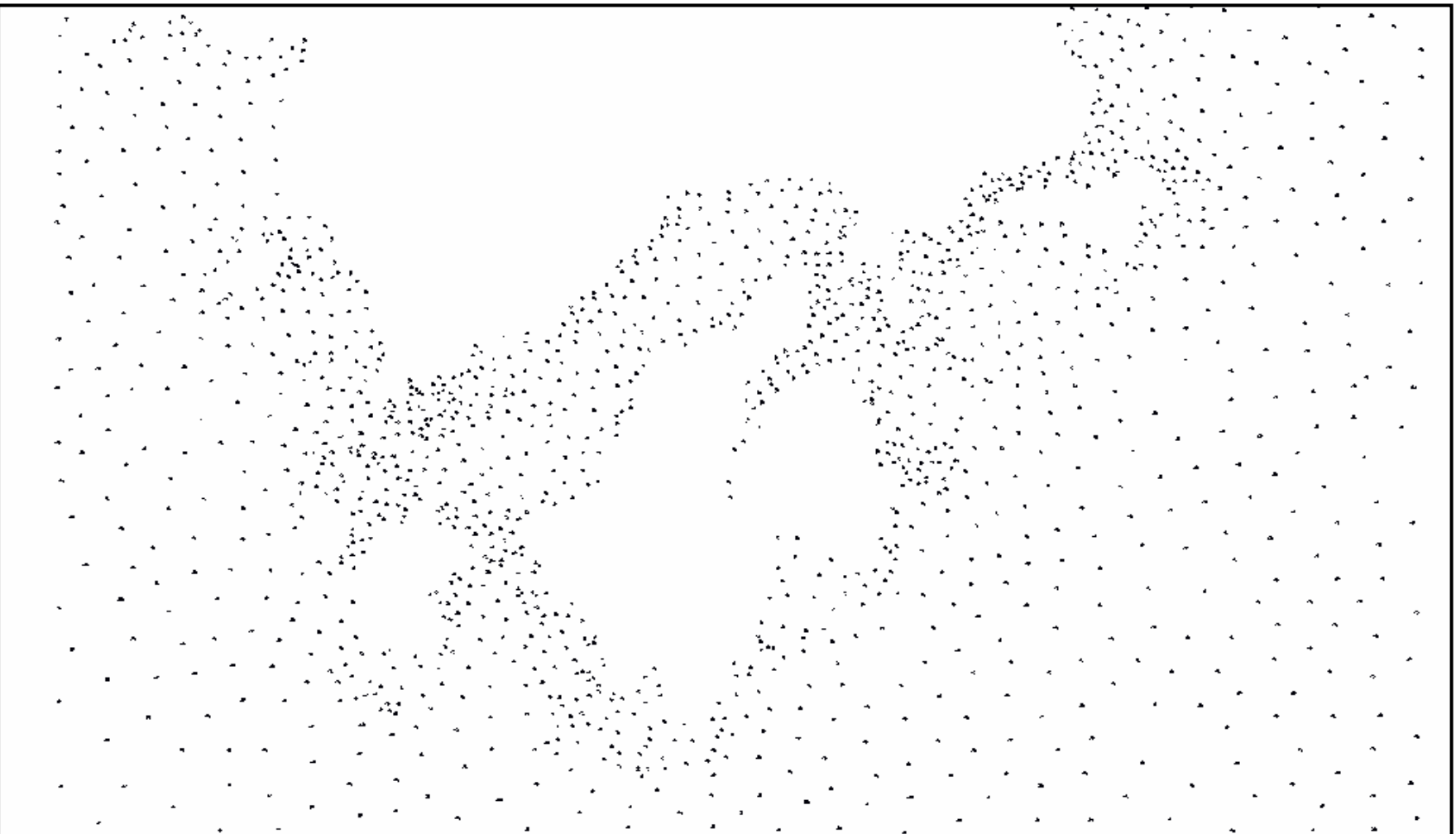
- 7) .Do you think that it is needed to launch a proper information system to manage both nautical charts and notices to mariner?
- 7) Do you think there is a need to launch a proper information system to manage both Nautical Charts and Notice to Mariners
- ☐ Yes ☐ No
- 8) How often do you look into Notice to Mariners for correction of Nautical Charts?
- ☐ Every time I look into Nautical Charts
- ☐ Seldom
- ☐ Never
- 9) Is there any insufficiency/ difficulties that you encounter with regards to the usage of Notice to Mariners that have influenced your work?
- ☐ Yes ☐ No
- 10) Based on question 9, if the answer is yes, what is your opinion in order to solve the above difficulties?
- 
- 
- 11) In your opinion, what is the most needed analysis use for the Nautical Chart and Notice to Mariners?
- 
- 
- 12) Do you think the management of Nautical Charts and Notice to Mariners based on Web is a solution for data sharing?
- ☐ Yes ☐ No

Thank you very much for your co-operation!

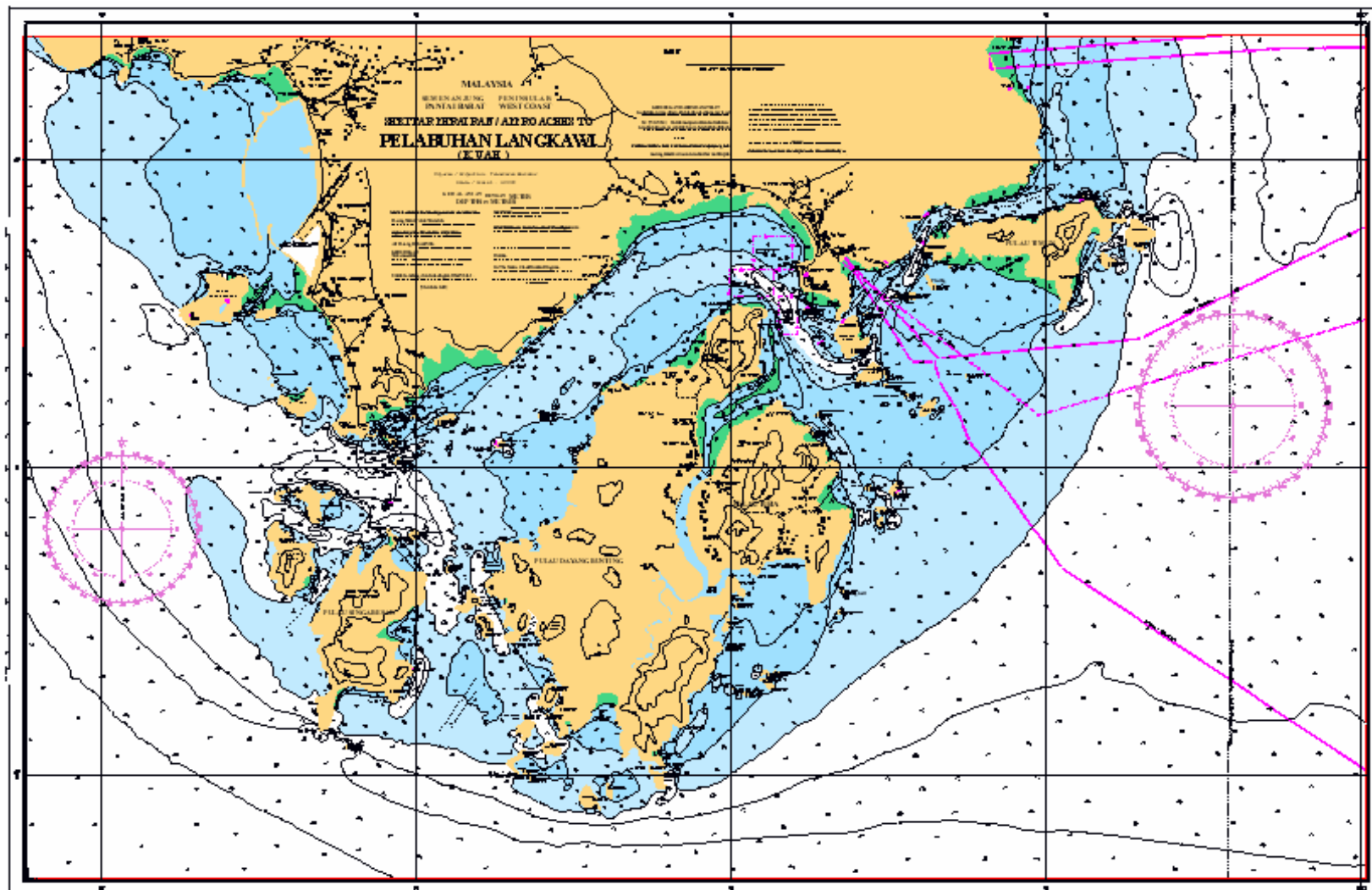




Result of Digitisation

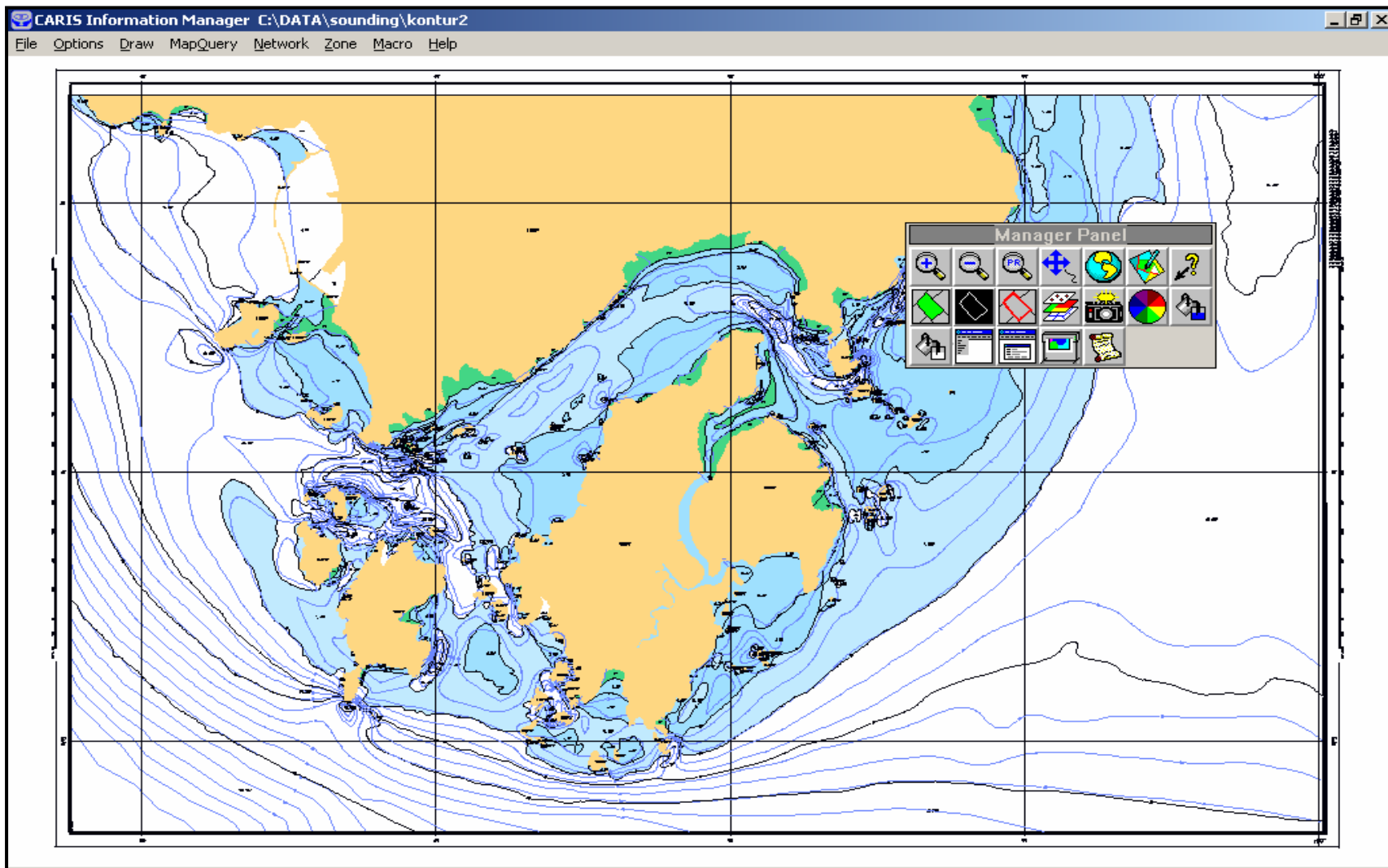
**LAMPIRAN E**

**Depth Value that Inputted Using Add Sounding**



LAMPIRAN H

Result of Digital Nautical Chart for MAL 5622



## APPENDIX I

Comparison between Original Contour(Black) with Generated Contour(Blue) with the Depth Interval of 2 Moter



## APPENDIX C

### Process of Thinning Raster Data

**CARIS for Windows: THINRAST V 4.4 a Date: 17-Jul-2001**  
**Copyright (c) 2003, Universal Systems Ltd., Fredericton, N.B. Canada.**

Initializing feature 1...

|                             |               |                      |
|-----------------------------|---------------|----------------------|
| 10 Percentage of iteration  | 1 on object 1 | complete at 12:09:14 |
| 20 Percentage of iteration  | 1 on object 1 | complete at 12:09:14 |
| 30 Percentage of iteration  | 1 on object 1 | complete at 12:09:14 |
| 40 Percentage of iteration  | 1 on object 1 | complete at 12:09:15 |
| 50 Percentage of iteration  | 1 on object 1 | complete at 12:09:15 |
| 60 Percentage of iteration  | 1 on object 1 | complete at 12:09:15 |
| 70 Percentage of iteration  | 1 on object 1 | complete at 12:09:15 |
| 80 Percentage of iteration  | 1 on object 1 | complete at 12:09:15 |
| 90 Percentage of iteration  | 1 on object 1 | complete at 12:09:15 |
| 100 Percentage of iteration | 1 on object 1 | complete at 12:09:15 |

8424 pixels removed

|                             |               |                      |
|-----------------------------|---------------|----------------------|
| 10 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 20 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 30 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 40 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 50 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 60 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 70 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 80 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 90 Percentage of iteration  | 2 on object 1 | complete at 12:09:16 |
| 100 Percentage of iteration | 2 on object 1 | complete at 12:09:16 |

2059 pixels removed

|                             |               |                      |
|-----------------------------|---------------|----------------------|
| 10 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 20 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 30 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 40 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 50 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 60 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 70 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 80 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 90 Percentage of iteration  | 3 on object 1 | complete at 12:09:17 |
| 100 Percentage of iteration | 3 on object 1 | complete at 12:09:17 |

1 pixels removed

10 Percentage of iteration 4 on object 1 complete at 12:09:17  
 20 Percentage of iteration 4 on object 1 complete at 12:09:17  
 30 Percentage of iteration 4 on object 1 complete at 12:09:17  
 40 Percentage of iteration 4 on object 1 complete at 12:09:17  
 50 Percentage of iteration 4 on object 1 complete at 12:09:17  
 60 Percentage of iteration 4 on object 1 complete at 12:09:17  
 70 Percentage of iteration 4 on object 1 complete at 12:09:17  
 80 Percentage of iteration 4 on object 1 complete at 12:09:17  
 90 Percentage of iteration 4 on object 1 complete at 12:09:17  
 100 Percentage of iteration 4 on object 1 complete at 12:09:17

0 pixels removed

Initializing feature 2...

10 Percentage of iteration 1 on object 2 complete at 12:09:28  
 20 Percentage of iteration 1 on object 2 complete at 12:09:28  
 30 Percentage of iteration 1 on object 2 complete at 12:09:28  
 40 Percentage of iteration 1 on object 2 complete at 12:09:28  
 50 Percentage of iteration 1 on object 2 complete at 12:09:28  
 60 Percentage of iteration 1 on object 2 complete at 12:09:29  
 70 Percentage of iteration 1 on object 2 complete at 12:09:29  
 80 Percentage of iteration 1 on object 2 complete at 12:09:29  
 90 Percentage of iteration 1 on object 2 complete at 12:09:29  
 100 Percentage of iteration 1 on object 2 complete at 12:09:29

0 pixels removed

500 descriptors output at 12:09:39  
 1000 descriptors output at 12:09:40  
 1500 descriptors output at 12:09:40  
 2000 descriptors output at 12:09:41  
 2500 descriptors output at 12:09:41  
 3000 descriptors output at 12:09:41  
 3500 descriptors output at 12:09:42  
 4000 descriptors output at 12:09:42  
 4500 descriptors output at 12:09:42  
 5000 descriptors output at 12:09:43  
 5500 descriptors output at 12:09:43  
 6000 descriptors output at 12:09:43

**thinrast completed**



## APPENDIX F

### Process for Creating A New Map

**CARIS for Windows: MAKECARI V 4.4 a Date: 17-Jul-2001**  
**Copyright (c) 2001, Universal Systems Ltd., Fredericton, N.B. Canada.**  
 Superseding existing CARIS file ...  
 No default header. Please enter header information.

Enter file title [DOS/16-Sep-2003 05:11:01] :  
 Enter file ID (up to 12 chars) [LANGKAWI\_HD]: PROJECT\_ENC  
 Enter horizontal coord system [NEMR]: CHMR  
 Enter projection [UM]: TM

```

      0-00-00.000E      0-00-00.000E
      |                |
0-00-00.000N -(4)-----<------(3)- 0-00-00.000N
      |                |
      MAP AREA
      |                |
0-00-00.000N -(1)----->------(2)- 0-00-00.000N
      |                |
      0-00-00.000E      0-00-00.000E
  
```

Enter corner 1 latitude [ 0-00-00.000N]:  
 6-08-18N  
 Enter corner 1 longitude [ 0-00-00.000W]:  
 99-38-48E  
 Enter corner 2 latitude [ 6-08-18.000N]:  
 Enter corner 2 longitude [ 0-00-00.000W]:  
 100-00-06E  
 Enter corner 3 latitude [ 0-00-00.000N]:  
 6-22-12N  
 Enter corner 3 longitude [100-00-06.000E]:  
 Enter corner 4 latitude [ 6-22-12.000N]:  
 Enter corner 4 longitude [ 99-38-48.000E]:

```

      99-38-48.000E      100-00-06.000E
      |                |
6-22-12.000N -(4)-----<------(3)- 6-22-12.000N
      |                |
      MAP AREA
      |                |
6-08-18.000N -(1)----->------(2)- 6-08-18.000N
      |                |
  
```

99-38-48.000E 100-00-06.000E

174

Are these corners ok? [Y]:

Y

Enter scaling factor for projection [0.9999]:

Enter central meridian [ 99-49-27.000E]:

Enter scaling latitude 1 [ 6-08-18.000N]:

Enter scale denominator [50000.]:

40000 Enter ellipsoid [CL66]:

EVRK

Enter chart resolution (in metres) [0.00001016]:

Enter resolution for elevations (in metres) [0.001]:

=====  
===

### Header

=====  
===

1. Title DOS/16-Sep-2003 05:11:01

2. File ID PROJECT\_ENC 3. Horizontal coord system

CHMR

4. Header length 184

5. Vertical coord system MR

6. Descriptor length 16

7. Sounding, Spot Ht units MR,M2

8. Coordinate resolutions

9. Coordinate shifts

XY 0.0000101600

X 0.000000000

Y 0.000000000

Z 0.0010000000

Z 0.000000000

10. Projection TM

11. Central meridian 99-49-

27.000E

12. Scale 40000.00

13. Scaling lat 1 6-08-18.000N

14. Scaling factor 0.999900

15. Scaling Lat 2 N/A

16. Ellipsoid EVRK

17. Vertical datum MSL

18. Alignment line XY

19. Alignment line Lat,Long

3680 3680

6-08-18.000N 99-38-48.000E

100344 3680

6-08-18.000N 100-00-06.000E

20. Graphic extent (3680,3680,100344,66709) (system)

21. Neatline corners (system)

21. Neatline corners Lat,Long

X= 3680 Y= 3680

6-08-18.000N 99-38-48.000E

X= 100344 Y= 3680

6-08-18.000N 100-00-06.000E

X= 100323 Y= 66709

6-22-12.000N 100-00-06.000E

X= 3701 Y= 66709

6-22-12.000N 99-38-48.000E

22. Format ID 5

23. Last edited 16-SEP-2003

05:11

Enter field number to change or Q to quit [list header]:

Q

Working ...

**makecari completed**

## APPENDIX G

### Process of Map Registration

**CARIS for Windows: RECTVECT V 4.4 a.2.1 Date: 2-May-2003  
Copyright (c) 2003, Universal Systems Ltd., Fredericton, N.B. Canada.**

Input CARIS file will be C:\DATA\langkawi\_vr  
Output CARIS file will be C:\DATA\langkawi\_reg

Reading coordinate data from control files.

Loading data points into vertex arrays...

Processing data ...

|                         |                       |
|-------------------------|-----------------------|
| 200 descriptors out of  | 2403 read at 14:34:37 |
| 400 descriptors out of  | 2403 read at 14:34:37 |
| 600 descriptors out of  | 2403 read at 14:34:37 |
| 800 descriptors out of  | 2403 read at 14:34:37 |
| 1000 descriptors out of | 2403 read at 14:34:37 |
| 1200 descriptors out of | 2403 read at 14:34:37 |
| 1400 descriptors out of | 2403 read at 14:34:37 |
| 1600 descriptors out of | 2403 read at 14:34:37 |

LANG 1033 not found in CARIS Language File

|                         |                       |
|-------------------------|-----------------------|
| 1800 descriptors out of | 2403 read at 14:34:37 |
| 2000 descriptors out of | 2403 read at 14:34:38 |
| 2400 descriptors out of | 2403 read at 14:34:38 |

-- 500 Lines left at 14:34:38

-- 0 Lines left at 14:34:38

**rectvect completed**

## APPENDIX J

### Analyses of Attribute using Polygon Key

CARIS Database Manager - [DataList3]

File Query Data View Window Help

|   | PID     | KEY | PERI      | AREA    |
|---|---------|-----|-----------|---------|
| 1 | 9.000   | KK  | 1640.000  | 6.000   |
|   | 29.000  | KK  | 536.000   | 2.000   |
|   | 30.000  | KK  | 919.000   | 4.000   |
|   | 32.000  | KK  | 634.000   | 1.000   |
|   | 34.000  | KK  | 10052.000 | 155.000 |
|   | 41.000  | KK  | 2321.000  | 24.000  |
|   | 46.000  | KK  | 4890.000  | 38.000  |
|   | 56.000  | KK  | 1525.000  | 8.000   |
|   | 76.000  | KK  | 2428.000  | 18.000  |
|   | 77.000  | KK  | 1557.000  | 10.000  |
|   | 86.000  | KK  | 598.000   | 2.000   |
|   | 88.000  | KK  | 1119.000  | 5.000   |
|   | 98.000  | KK  | 7877.000  | 57.000  |
|   | 101.000 | KK  | 5664.000  | 96.000  |
|   | 118.000 | KK  | 1266.000  | 6.000   |
|   | 119.000 | KK  | 1144.000  | 6.000   |
|   | 121.000 | KK  | 1484.000  | 6.000   |
|   | 122.000 | KK  | 6335.000  | 64.000  |
|   | 123.000 | KK  | 11919.000 | 191.000 |
|   | 124.000 | KK  | 194.000   | 0.000   |
|   | 125.000 | KK  | 194.000   | 0.000   |
|   | 126.000 | KK  | 1299.000  | 5.000   |
|   | 130.000 | KK  | 576.000   | 2.000   |
|   | 132.000 | KK  | 265.000   | 0.000   |
|   | 134.000 | KK  | 234.000   | 0.000   |
|   | 135.000 | KK  | 6096.000  | 69.000  |
|   | 136.000 | KK  | 466.000   | 1.000   |
|   | 162.000 | KK  | 1349.000  | 5.000   |
|   | 163.000 | KK  | 1535.000  | 7.000   |

Ready

NUM

**Statistical Properties for a Field**

Field Name: AREA

Number of Samples: 69

Minimum Sample: 0.

Maximum Sample: 191.

Total of Samples: 1531.

Mean of Samples: 22.1884057971014

Standard Deviation: 39.7685492651723

OK

CARIS Database Manager - [DataList2]

File Query Data View Window Help

|   | PID     | KEY  | PERI     | AREA   |
|---|---------|------|----------|--------|
| 1 | 27.000  | D_2M | 2280.000 | 10.000 |
|   | 31.000  | D_2M | 1542.000 | 2.000  |
|   | 37.000  | D_2M | 2273.000 | 9.000  |
|   | 39.000  | D_2M | 803.000  | 3.000  |
|   | 42.000  | D_2M | 1622.000 | 11.000 |
|   | 44.000  | D_2M | 3764.000 | 19.000 |
|   | 45.000  | D_2M | 1464.000 | 9.000  |
|   | 49.000  | D_2M | 494.000  | 1.000  |
|   | 94.000  | D_2M | 3828.000 | 11.000 |
|   | 115.000 | D_2M | 454.000  | 1.000  |
|   | 151.000 | D_2M | 1215.000 | 7.000  |
|   | 181.000 | D_2M | 1427.000 | 7.000  |
|   | 182.000 | D_2M | 663.000  | 1.000  |
|   | 183.000 | D_2M | 360.000  | 1.000  |
|   | 184.000 | D_2M | 652.000  | 3.000  |
|   | 190.000 | D_2M | 1274.000 | 4.000  |
|   | 191.000 | D_2M | 2341.000 | 26.000 |
|   | 193.000 | D_2M | 4008.000 | 27.000 |
|   | 197.000 | D_2M | 1517.000 | 11.000 |
|   | 199.000 | D_2M | 498.000  | 1.000  |
|   | 203.000 | D_2M | 1469.000 | 4.000  |
|   | 207.000 | D_2M | 3361.000 | 19.000 |
|   | 212.000 | D_2M | 563.000  | 2.000  |
|   | 213.000 | D_2M | 402.000  | 1.000  |
|   | 214.000 | D_2M | 409.000  | 1.000  |
|   | 230.000 | D_2M | 616.000  | 1.000  |
|   | 231.000 | D_2M | 861.000  | 3.000  |
|   | 232.000 | D_2M | 481.000  | 1.000  |
|   | 233.000 | D_2M | 4220.000 | 50.000 |

Ready

NUM

**Statistical Properties for a Field**

Field Name: AREA

Number of Samples: 77

Minimum Sample: 1.

Maximum Sample: 1098.

Total of Samples: 3210.

Mean of Samples: 41.6883116883117

Standard Deviation: 153.581134030215

OK

## APPENDIX K

### Listing Program Nautical – WebGIS

#### (i) Program of Dynamic Map

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">

<html>
<head>
    <meta http-equiv="Content-Language" content="en-us">
    <title>::: NAUTICAL-WEBGIS FOR SUBSCRIBER :::</title>
    <LINK href="scripts/tempStyles.css" type="text/css" rel="stylesheet">
    <SCRIPT language="javascript" src="scripts/dynamic.js"></SCRIPT>
    <SCRIPT language="javascript" src="scripts/mgcmd.js"></SCRIPT>
</head>

<body bgcolor="#B0C4DE">
<script language="JavaScript">

// preload images:
if (document.images) {
Select1 = new Image(50,50); Select1.src = "pic/select1.gif";
Select2 = new Image(50,50); Select2.src = "pic/select2.gif";
Pan1 = new Image(50,50); Pan1.src = "pic/pan1.gif";
Pan2 = new Image(50,50); Pan2.src = "pic/pan2.gif";
Zoomin1 = new Image(50,50); Zoomin1.src = "pic/zoomin1.gif";
Zoomin2 = new Image(50,50); Zoomin2.src = "pic/zoomin2.gif";
Zoomout1 = new Image(50,50); Zoomout1.src = "pic/zoomout1.gif";
Zoomout2 = new Image(50,50); Zoomout2.src = "pic/zoomout2.gif";
Zoomprev1 = new Image(50,50); Zoomprev1.src = "pic/zoomprev1.gif";
Zoomprev2 = new Image(50,50); Zoomprev2.src = "pic/zoomprev2.gif";
Fullmap1 = new Image(50,50); Fullmap1.src = "pic/fullmap1.gif";
Fullmap2 = new Image(50,50); Fullmap2.src = "pic/fullmap2.gif";
Zoomselect1 = new Image(50,50); Zoomselect1.src = "pic/zoomselect1.gif";
Zoomselect2 = new Image(50,50); Zoomselect2.src = "pic/zoomselect2.gif";
Print1 = new Image(50,50); Print1.src = "pic/print1.gif";
Print2 = new Image(50,50); Print2.src = "pic/print2.gif";
Help1 = new Image(50,50); Help1.src = "pic/help1.gif";
Help2 = new Image(50,50); Help2.src = "pic/help2.gif";
Point1 = new Image(70,18); Point1.src = "pic/point1.gif";
Point2 = new Image(70,18); Point2.src = "pic/point2.gif";
Polyline1 = new Image(70,18); Polyline1.src = "pic/polyline.gif";
Polyline2 = new Image(70,18); Polyline2.src = "pic/polyline2.gif";
Polygon1 = new Image(70,18); Polygon1.src = "pic/polygon1.gif";
Polygon2 = new Image(70,18); Polygon2.src = "pic/polygon2.gif";
```

```

}

function getMap()

{
  if (navigator.appName == "Netscape")
    return document.MGADVMap;
  else
    return document.all.map;
}

function gotoLocation()
{
  var map = getMap();
  var index = document.region.LocSel.selectedIndex;

  if (index == 1)
    map.zoomScale(500000, 400000, 6554000.0);

  if (index == 2)
    map.zoomScale(570000, 1800000, 7878600.0);

  if (index == 3)
    map.zoomScale(660700.0, 2130000.0, 3811000.0);

  if (index == 4)
    map.zoomScale(661600, 206000, 1243000.0);

  if (index == 5)
    map.zoomScale(394000, 343000, 1624400.0);

  if (index == 6)
    map.zoomScale(204421, 543310.0, 1300000.0);

  if (index == 7)
    map.zoomScale(180000, 650000, 807000.0);

  if (index == 8)
    map.zoomScale(464000, 558000, 1200000.0);

  if (index == 9)
    map.zoomScale(310000, 1540000, 2300000.0);

  if (index == 10)
    map.zoomScale(614630, 2170000, 2800000.0);

```

```
}
```

```
function Hilite(imgName,imgObjName) {
if (document.images) {
  document.images[imgName].src = eval(imgObjName + ".src");
}}
```

```
</script>
```

```
<script language="VBScript">
```

```
Sub map_onDigitizedPoint (map, point)
  onDigitizedPoint map, point
End Sub
```

```
Sub map_onDigitizedPolyline (map, numPoints, points)
  onDigitizedPolyline map, numPoints, points
End Sub
```

```
Sub map_onDigitizedPolygon (map, numPoints, points)
  onDigitizedPolygon map, numPoints, points
End Sub
```

```
</script>
```

```
<script language="JavaScript">
```

```
function onDigitizedPolyline(map, numPoints, points)
{
var formText = reportWindow.parent.document.thePolylineForm.theTextbox.value;
var selOptions = reportWindow.parent.document.thePolylineForm.theStyle.options;
  for (var i=0; i < selOptions.length; i++)
  {
    if (selOptions[i].selected)
    {
      var txtStyle = selOptions[i].value;
    }
  }
var selOptions = reportWindow.parent.document.thePolylineForm.theColor.options;
  for (var i=0; i < selOptions.length; i++)
  {
    if (selOptions[i].selected)
    {
```

```

        var txtColor = selOptions[i].value;
    }
}

var txtThickness = reportWindow.parent.document.thePolylineForm.theThickness.value;

var myLayer = map.getMapLayer("Redline");
if (myLayer == null)
myLayer = map.createLayer("redline", "Redline");
var myRedline = map.getRedlineSetup();

var myLine = myRedline.getLineAttr();
    myLine.setStyle(txtStyle);
    myLine.setThickness(parseInt(txtThickness));
    myLine.setColor(parseInt(txtColor));
var obj = myLayer.getMapObject(formText);
if (obj == null)
    var obj = myLayer.createMapObject(formText, formText, "");

var user_vertices = map.createObject("mgcollection");
user_vertices.add(numPoints);
obj.addPolylinePrimitive(points, user_vertices, false);
}

function onDigitizedPoint(map, point)
{
var formText = reportWindow.parent.document.thePointForm.theTextbox.value;
var sizeValue = reportWindow.parent.document.thePointForm.theSize.value;

var selOptions = reportWindow.parent.document.thePointForm.theSymbol.options;
for (var i=0; i < selOptions.length; i++){
    if (selOptions[i].selected)
    {
        var symbolType = selOptions[i].value;
    }
}

var selOptions = reportWindow.parent.document.thePointForm.theUnit.options;
for (var i=0; i < selOptions.length; i++){
    if (selOptions[i].selected)
    {
        var sizeUnit = selOptions[i].value;
    }
}

var myLayer = map.getMapLayer("Redline");
if (myLayer == null)
    myLayer = map.createLayer("redline", "Redline");

```



```

var myRedline = map.getRedlineSetup();
var mySymbol = myRedline.getSymbolAttr();

mySymbol.setWidth(parseFloat(sizeValue), sizeUnit);
mySymbol.setHeight(parseFloat(sizeValue), sizeUnit);
mySymbol.setSymbol(symbolType);

var obj = myLayer.getMapObject(formText);
if (obj == null)
    var obj = myLayer.createMapObject(formText, formText, "");

obj.addSymbolPrimitive(point, false);
}

function onDigitizedPolygon(map, numPoints, points)
{
var formText = reportWindow.parent.document.thePolygonForm.theTextbox.value;

var selOptions = reportWindow.parent.document.thePolygonForm.theBackMode.options;
    for (var i=0; i < selOptions.length; i++)
    {
        if (selOptions[i].selected)
        {
            var txtBackMode = selOptions[i].value;
        }
    }

var selOptions = reportWindow.parent.document.thePolygonForm.theHatchPat.options;
    for (var i=0; i < selOptions.length; i++)
    {
        if (selOptions[i].selected)
        {
            var txtHatchPat = selOptions[i].value;
        }
    }

var selOptions = reportWindow.parent.document.thePolygonForm.theStyle.options;
    for (var i=0; i < selOptions.length; i++)
    {
        if (selOptions[i].selected)
        {
            var txtStyle = selOptions[i].value;
        }
    }
}

```

```

var selOptions = reportWindow.parent.document.thePolygonForm.theColor.options;
    for (var i=0; i < selOptions.length; i++)
    {
        if (selOptions[i].selected)
        {
            var txtColor = selOptions[i].value;
        }
    }

var myLayer = map.getMapLayer("Redline");
if (myLayer == null)
myLayer = map.createLayer("redline", "Redline");

var myRedline = map.getRedlineSetup();
var myFill = myRedline.getFillAttr();

myFill.setHatchPattern(txtHatchPat);
myFill.setBackMode(txtBackMode);
myFill.setStyle(txtStyle);
myFill.setColor(parseInt(txtColor));

var obj = myLayer.getMapObject(formText);
if (obj == null)
var obj = myLayer.createMapObject(formText, formText, "");

var user_vertices = map.createObject("mgcollection");
user_vertices.add(numPoints);

obj.addPolygonPrimitive(points, user_vertices, false);
}

function formHandler(form){
    var URL = document.form.site.options[document.form.site.selectedIndex].value;
    window.open(URL,'WinName','toolbar=no,location=no,directories=no,status=no,men
ubar=no,scrollbars=yes,resizable=yes,width=500,height=200');
    document.form.site.selectedIndex = 0;
}
</script>
<div align="center">
<div align="left">
<TABLE Cellspacing="0" >
<tr>
    <td ><a href="javascript:var dummy=getMap().selectMode()"
onMouseOver="Hilite('Select','Select2')" onMouseOut="Hilite('Select','Select1')">
        </a></td>

```

```

        <td ><a href="javascript:getMap().panMode()" onMouseOver="Hilite('Pan','Pan2')"
onMouseOut="Hilite('Pan','Pan1')">
            </a></td>
        <td ><a href="javascript:var dummy=getMap().zoomPrevious()"
onMouseOver="Hilite('Zoomprev','Zoomprev2')"
onMouseOut="Hilite('Zoomprev','Zoomprev1')">
            </a></td>
        <td ><a href="javascript:getMap().zoomInMode()"
onMouseOver="Hilite('Zoomin','Zoomin2')"
onMouseOut="Hilite('Zoomin','Zoomin1')">
            </a></td>
        <td ><a href="javascript:getMap().zoomOutMode()"
onMouseOver="Hilite('Zoomout','Zoomout2')"
onMouseOut="Hilite('Zoomout','Zoomout1')">
            </a></td>
        <td ><a href="javascript:getMap().zoomOut()"
onMouseOver="Hilite('Fullmap','Fullmap2')"
onMouseOut="Hilite('Fullmap','Fullmap1')">
            </a></td>
        <td ><a href="javascript:getMap().zoomSelected()"
onMouseOver="Hilite('Zoomselect','Zoomselect2')"
onMouseOut="Hilite('Zoomselect','Zoomselect1')">
            </a></td>
        <td ><a href="javascript:getMap().printDlg()"
onMouseOver="Hilite('Print','Print2')" onMouseOut="Hilite('Print','Print1')">
            </a></td>
        <td ><a href="javascript:var
helpWindow=open("http://172.16.0.140/mgweb/htm/help.htm",
"thewindow","width=400,height=500,scrollbars=yes")'
onMouseOver="Hilite('Help','Help2')" onMouseOut="Hilite('Help','Help1')">
            </a></td>

</tr>
</table>
<div style="position: absolute; width: 95px; height: 59px; z-index: 2; left: 617px; top:
11px" id="layer2">

```

```

<a href= "http://172.16.0.140/mgweb/htm/index.htm">
</a>
<a href= "http://172.16.0.140/mgweb/htm/feedback.htm">
</div></a>
</div>
</div align>

<object id="map" width="73%" height=500
classid="CLSID:62789780-B744-11D0-986B-00609731A21D"
codebase="ftp://adskftp.autodesk.com/webpub/mapguide/ver6/mgaxctrl.cab#Version=6,
0,2,2" >
  <param name="URL" value="http://172.16.0.140/mgweb/mwf/MGmap.mwf">
  <param name="Lat" value="0">
  <param name="Lon" value="0">
  <param name="MapScale" value="0">
  <param name="MapWidth" value="0">
  <param name="Units" value="M">
  <param name="ToolBar" value="Off">
  <param name="StatusBar" value="On">
  <param name="LayersViewWidth" value="160">
  <param name="URLListState" value="0">
  <param name="AutoLinkDelay" value="20">
  <embed
src="http://172.16.0.140/mgweb/mwf/MGmap.mwf?toolbar=off&LayersViewWidth=0"
align="baseline" border="0" width="100%" height="100%" name="map"
type="application/x-mwf">
  </embed>
</object>
<div style="position: absolute; width: 253px; height: 482px; z-index: 1; left: 740px; top:
73px" id="layer1">

<table id="Menu" cellspacing="0" cellpadding="0" width="200" border="0">
<tr>
<td width="30" background="pic/nmnutitle-1.gif" height="20">&nbsp;</td>
<td class="mnuTitle" width="140" background="pic/nmnutitle.gif"
height="20">Advanced Tools </td>
<td width="30" background="pic/nmnutitle-1.gif" height="20"></td></tr>
<tr> <td align="middle" colspan="3">
<table class="subMnu" id="table11" cellspacing="2" cellpadding="2" bgcolor="#0066ff"
border="0">
<tr height="20">
<td><input class="button" type="button" value="zoom scale" id="Button1"
name="Button1" onClick="getMap().zoomScaleDlg()"></td>
<td><input class="button" type="button" value="clear selection" id="Button7"
name="Button7" onClick="ClearSelection()"></td></tr>

```

```

<tr height="20">
<td><input class="button" type="button" value="buffer" id="Button3" name="Button32"
onClick="ViewBuffer()"></td>
<td><input class="button" type="button" value="measure" id="Button4"
name="Button4" onClick="getMap().viewDistance()"></td></tr>
<tr height="20">
<td><input class="button" type="button" value="select within" id="Button5"
name="Button5" onClick="SelectWithin()"></td>
<td><input class="button" type="button" value="copy map" id="Button8"
name="Button8" onClick="getMap().copyMap()"></td></tr>
</table> </td> </tr>
<tr>
<td width="30" background="pic/nmnutitle-l.gif" height="20">&nbsp;  </td>
<td class="mnuTitle" width="140" background="pic/nmnutitle.gif"
height="20">Drawing Tools </td>
<td width="30" background="pic/nmnutitle-l.gif" height="20"></td> </tr>
<tr> <td align="middle" colspan="3">
<table class="subMnu" id="table12" cellspacing="2" cellpadding="2" bgcolor="#0066ff"
border="0" >
<tr height="20">
<td><a href='javascript:var reportWindow=open("draw_point.htm", "theWindow",
"width=220,height=200")' onMouseOver="Hilite('Point','Point2')
onMouseOut="Hilite('Point','Point1')">
</a></td>
<td class="inputText" width="81" >
<input class="button" id="Button24" type="button" value="Delete" name="Button40"
onClick="DeleteRedline()"></td></tr>
<tr height="20">
<td><a href='javascript:var reportWindow=open("draw_polyline.htm", "theWindow",
"width=250,height=200")' onMouseOver="Hilite('Polyline','Polyline2')
onMouseOut="Hilite('Polyline','Polyline1')">
</a></td>
<td class="inputText" width="81">
<input class="button" id="Button25" type="button" value="Clear" name="Button41"
onClick="ClearRedline()"></td> </tr>
<tr height="20">
<td><a href='javascript:var reportWindow=open("draw_polygon.htm", "theWindow",
"width=250,height=220")' onMouseOver="Hilite('Polygon','Polygon2')
onMouseOut="Hilite('Polygon','Polygon1')">
</a></td>
<td class="inputText" width="81">
<p></td> </tr> </table>
</td></tr>

```

```

<tr>
<td width="30" background="pic/nmnutitle-l.gif" height="20">&nbsp;  </td>
<td class="mnuTitle" width="140" background="pic/nmnutitle.gif" height="20">
    Search Tools </td>
<td width="30" background="pic/nmnutitle-l.gif" height="20"></td></tr>
<tr> <td align="middle" colspan="3">
<table class="subMnu" id="table15" cellspacing="2" cellpadding="2"
    bgcolor="#0066ff" border="0">
<tr height="20">
<form name="form"><td valign="top"><div style="padding-top:2px; padding-
    left:3px;">
<select name="site" size=1 onChange="javascript:formHandler()">
    <option>Search For...
    <option value="search_chart.htm">Nautical Chart
    <option value="Search_notice.htm">Notice to Mariners
</select>
</div></td></form></td>
</tr>
</table> </td> </tr>

<tr>
<td width="30" background="pic/nmnutitle-l.gif" height="20">&nbsp;  </td>
<td class="mnuTitle" width="140" background="pic/nmnutitle.gif" height="20">
    Zooming To Region</td>
<td width="30" background="pic/nmnutitle-l.gif" height="20"></td></tr>
<tr> <td align="middle" colspan="3">
<table class="subMnu" id="table18" cellspacing="2" cellpadding="2" bgcolor="#0066ff"
border="0">
<tr height="20">
<form name="region"><td valign="top"><div style="padding-top:2px; padding-
left:3px;">
<SELECT NAME="LocSel" ONCHANGE="gotoLocation()">
    <OPTION>Select a Region
    <OPTION>Peninsular Malaysia
    <OPTION>Sarawak
    <OPTION>Sabah
    <OPTION>Zone5-North West Coast
    <OPTION>Zone5-Center West Coast
    <OPTION>Zone5-South West Coast
    <OPTION>Zone5/6-Singapore
    <OPTION>Zone6- East Coast
    <OPTION>Zone7-Sarawak
    <OPTION>Zone8-Sabah

```

```

</SELECT></div></td></form></td>
</tr>
</table> </td> </tr>

<tr>
<td width="30" background="pic/nmnutitle-1.gif" height="20">&nbsp;</td>
<td class="mnuTitle" width="140" background="pic/nmnutitle.gif" height="20">
View Report</td>
<td width="30" background="pic/nmnutitle-1.gif" height="20"></td></tr>
<tr> <td align="middle" colspan="3">
<table class="subMnu" id="table21" cellspacing="2" cellpadding="2" bgcolor="#0066ff"
border="0" width="158">
<tr height="20">
<form name="form0"><td valign="top">
<input class="button" type="button" value="Report" id="Button3" name="Button3"
onClick="LaunchReport()"><p>
<font color="#FF0000">** </font>Note: Please select features in
only one layer to view the detail report.</td></form></td>
</tr>
</table> </td> </tr>
</table>
<SCRIPT language="javascript">
SetMenu('Menu');
</SCRIPT>
</body>
</html>

```

**(iii) Program of Interactive Query**

```

var refreshTimeout;
var pointType;
var objCounter = 0;

function getMap()

{
  if (navigator.appName == "Netscape")
    return document.MGADVMap;
  else
    return document.all.map;
}

function ViewBuffer()
{
  if (getMap().getSelection().getMapObjectsEx(null).size() == 0)
    alert('You must select an object before using this function');
  else
    var result = getMap().viewBufferDlg();
}

function SelectWithin()
{
  getMap().getSelectionMode()
  getMap().setSelectionMode("Intersection")
  getMap().selectWithinDlg ()
}

function ClearSelection(){

```



```

    getMap().getSelection().clear();
    getMap().removeMapLayer("Buffer");
}

```

```
function DeleteRedline()
```

```

{
    var rlLayer = getMap().getMapLayer('Redline');
    if(rlLayer)
    {
        var selobjs = getMap().getSelection().getMapObjectsEx(rlLayer);
        if (selobjs) rlLayer.removeObjects(selobjs);
    }
}

```

```
function ClearRedline()
```

```

{
    getMap().removeMapLayer('Redline');
}

```

```
function LaunchReport()
```

```

{
    var map = getMap();
    if (map.isBusy() == false)
    {

        var sel = map.getSelection();
        var NumSel = sel.getNumObjects();
        var obj_keys = ""
        var obj_key = ""
    }
}

```

```

if (NumSel > 0)
{
    var ObjectKeySelected = sel.getMapObjectsEx(layerReport);
    var layerName = ObjectKeySelected.item(0).getMapLayer().getName();
    var layerReport = map.getMapLayer(layerName);
    for (i = 0; i < NumSel; i++)
    {
        obj_key = "\"" + ObjectKeySelected.item(i).getKey() + "\""
        obj_keys += obj_key
        if (i < NumSel - 1) obj_keys += ","
    }

    //alert("Inside loop: " + obj_keys);
    //alert("Outside loop: " + obj_keys);

    var reportURL = ""
    if (layerName == 'Shore')

        reportURL =
"http://172.16.0.140/mgweb/htm/reportshore.asp?obj_keys=" + obj_keys;

    else if (layerName == 'Chartframeline')
        reportURL =
"http://172.16.0.140/mgweb/htm/reportchart.asp?obj_keys=" + obj_keys;

    else if (layerName == 'Light')
        reportURL =
"http://172.16.0.140/mgweb/htm/reportlight.asp?obj_keys=" + obj_keys;

    else if (layerName == 'Track')

```

```
        reportURL =  
        "http://172.16.0.140/mgweb/htm/reporttrack.asp?obj_keys=" + obj_keys;  
  
        else if (layerName == 'Obstructions')  
            reportURL =  
            "http://172.16.0.140/mgweb/htm/reportobstruction.asp?obj_keys=" + obj_keys;  
  
        else if (layerName == 'Services')  
            reportURL =  
            "http://172.16.0.140/mgweb/htm/reportservices.asp?obj_keys=" + obj_keys;  
  
        else if (layerName == 'Offshore Installation')  
            reportURL =  
            "http://172.16.0.140/mgweb/htm/reportoffshore.asp?obj_keys=" + obj_keys;  
  
        else if (layerName == 'Radio Radar')  
            reportURL =  
            "http://172.16.0.140/mgweb/htm/reportradar.asp?obj_keys=" + obj_keys;  
  
        else if (layerName == 'Limit Areas')  
            reportURL =  
            "http://172.16.0.140/mgweb/htm/reportlimitarea.asp?obj_keys=" + obj_keys;  
  
        else if (layerName == 'Notice to Mariners')  
            reportURL =  
            "http://172.16.0.140/mgweb/htm/reportnotice.asp?obj_keys=" + obj_keys;  
  
        else return;
```

```

        window.open(reportURL, null, "height=350, width=700, status=no,
toolbar=no, menubar=no,location=no, scrollbars=yes, resizable=yes");
    }
    else
    {
        alert("You need to select map features before you can view the attribute
data.");
        map.selectMode();
    }
}
else
    alert("The Autodesk MapGuide Viewer is busy. Please try again in a few
seconds.");

}

function zoomgoto(layername, X, Y, Key, Scale)

{
    alert(("Got into zoomtoKey"))
    map = opener.getMap();
    map.setAutorefresh(false);
    map.zoomscale( X, Y, Scale);

    map.refresh();
    window.setTimeout("zoomto( '" + layername + "', '" + Key + "'", 200);
    map.setAutorefresh(true);
}

```

```
function zoomto(Key)
{
    alert("Got into zoomto")
    map = opener.getMap();
    if (map.isBusy())
    {
        window.setTimeout("zoomto( '" + layername + "', '" + Key + "')", 150);
        return;
    }
    var feature = map.getMapLayer('Chartframeline').getMapObject(Key);
    var sel = map.getSelection();
    sel.clear();
    sel.addObject(feature, false);
    map.setAutorefresh(false);
    map.zoomSelected();
    map.setAutorefresh(true);
    map.refresh();
}
```

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